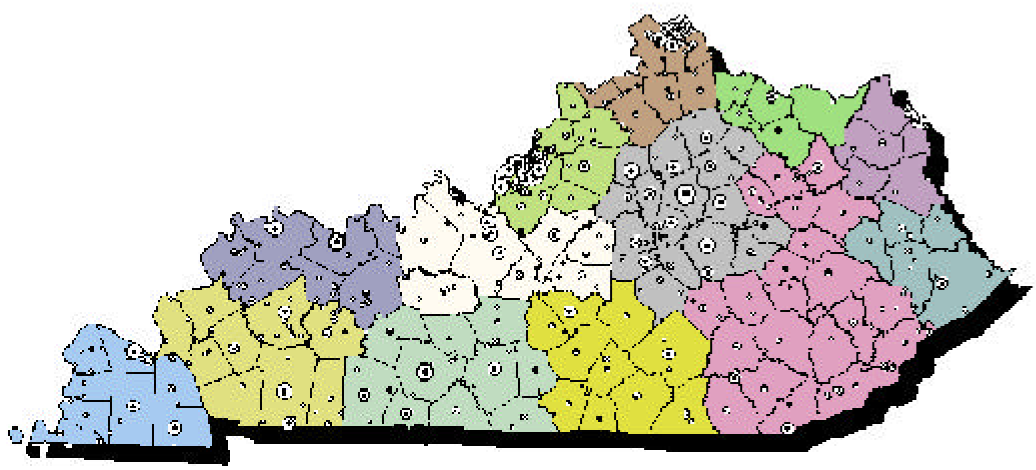
A Guide to GIS Technology and Its Use in Kentucky Local Governments



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Preface

This guide is intended to provide a brief overview of GIS technology and issues that impact its development and use by local governments. It is an introduction to GIS concepts, applications, and implementation and serves as a basic reference for local government users. It is particularly useful for personnel in cities and counties that are not currently using GIS technology but have an interest in doing so. This primer should also be a valuable resource for any local government staff person, manager, or elected official who is interested in a brief overview of GIS technology and how it can be used to address local needs.

This guide is the first of several items being developed by the Kentucky Office of Geographic Information that are designed to provide general GIS information to local government officials in the Commonwealth. Future items will include a half-day workshop that will provide those interested in establishing GIS at the local level with examples and illustrations of how they can cooperate and work together to develop an initial system.

What is GIS?

The majority of the information collected and used by local governments to support day-to-day operations, decision-making, and planning is geographically referenced. In other words, it is related to a location or feature on the surface of the Earth. For example, local government agencies depend on good quality information that is often associated with the ownership of a lot or parcel, a street address, a utility line, a building site, or another locational reference.

GIS is a core information technology with capabilities to effectively collect, organize, access, visualize, and analyze geographic information. In its simplest form, GIS technology supports automated mapping—the creation, update, and production of maps that provide great advantages over manual mapping methods. But a GIS can also manage and access information about map features.

> ***A GIS is much more than just maps.***
>
> GIS is much more than a mapping tool. GIS software has the ability both to store graphic representations of map features and to access diverse types of data and records that are geographically referenced. GIS allows users to access, examine, and analyze geographically referenced information.

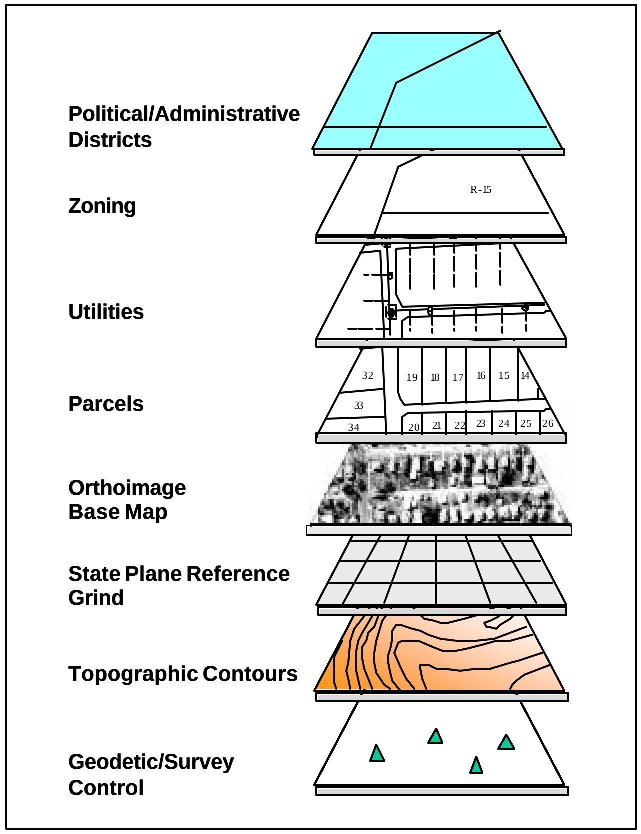


Figure 1: The Map Layer Concept

Simply put, GIS technology can extend the reach and ability of local government agencies to use information about the land and its man-made facilities and natural resources to help administer programs and support decisions that impact the local government's future.

The information in a GIS can be visualized as a series of overlaid map layers which share a common x,y coordinate system, as shown in Figure 1.

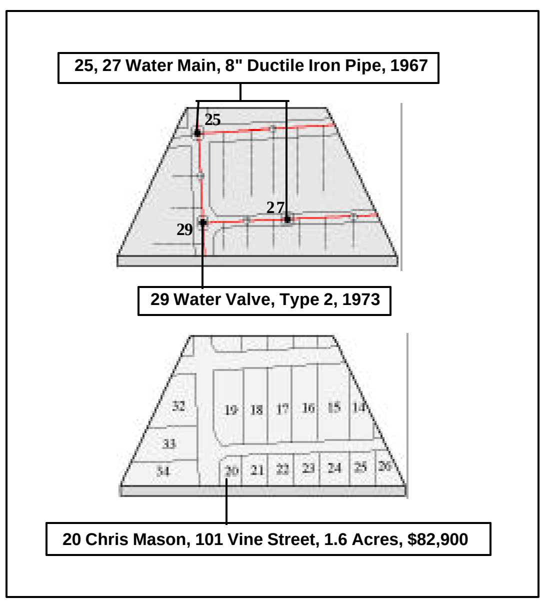


Figure 2: Attribute Data Linked to Map Features

A GIS database stores map features as well as information about those features, as Figure 2 shows. The feature information, providing descriptive or numerical information, is stored as database attribute records linked to the map feature. This ability of the GIS to manage both graphic information and attribute data means that the GIS is a powerful tool for producing maps and for conducting more complex database queries and analysis. GIS software can be used to easily import or directly access geographic records from other systems (e.g., permit, work order, business license, or parcel ownership information stored in databases or spreadsheets).

GIS Use by Local Governments

GIS technology can be used to support many local government departments and program areas that rely on geographic information, including:

- Property mapping and assessment
- Public safety and emergency planning and response
- Land development and building permit review and tracking
- Economic development and site suitability assessment
- Utility planning, maintenance, and customer service
- “What-if” analysis for long-term growth planning and decision support.

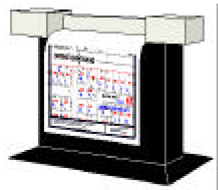
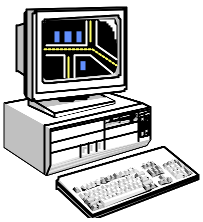
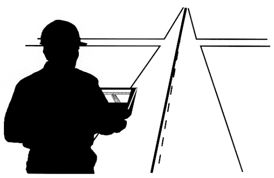
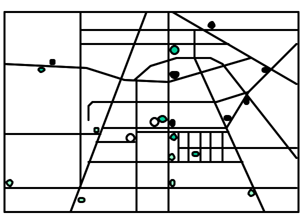
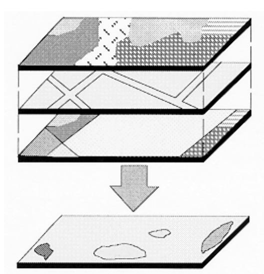
GIS technology is a tool that, when used wisely, gives local officials enhanced capability and improved efficiency in administering programs and planning for the future.

> GIS technology supports the business needs of local governments to administer services, efficiently respond to the needs of citizens, support economic development, and carry out long-term planning.

Examples of GIS Applications

The software, data, and computer hardware of a GIS provide a foundation for specific applications that meet the needs of local government users. The number and type of applications for which a GIS may be used are limited only by the needs and imagination of users. GISs have considerable flexibility to customize applications to deliver results and products in the form of computer displays, hard copy maps, tabular reports, or data files that can be exported to other applications. Table 1 presents some basic categories of GIS applications of interest to local governments.

Table 1: Typical Local Government GIS Applications

Applications of GIS Technology		Examples
	**Standard Map Update and Production**	• Standard tax parcel mapping • Zoning map update and production • Water and sewer network mapping • Land use mapping
	**Casual Data Query and Map Display**	• Road/Street condition and maintenance tracking • Parcel property ownership and characteristics • Land use and business license analysis • Portraying public expenditures by geographic area or political district
	**Field Access and Data Capture**	• Field inventory for facility information • Support for road maintenance or utility customer service personnel • Building permit inspections • Support for emergency response or disaster assessment • Property survey and field appraisal
	**Public Inquiry**	• Public kiosks in support of tourism • Public counter access for questions on permit status or available utility service • Web-based access to geographic information
	**Address Data Mapping and Analysis**	• Mapping and tracking of building permits • Crime incident mapping and pattern analysis • Utility customer mapping • Display of citizen calls or complaints • Business license query and display • School bus or waste pick-up routing
	**Spatial Analysis for Patterns and Trends**	• Disaster risk and response analysis • Public health service needs analysis • Environmental or critical area impact assessment • Traffic modeling and planning • Site suitability analysis for economic development
	**Custom Map Presentation**	• Wall maps or hand-outs for public hearings • Maps with special highlights and symbols to augment reports and plans • Special maps showing infrastructure status and proposed capital projects • Special maps to support tourism or economic development

Benefits Derived from Use of GIS

The benefits of GIS technology are profound. The wise use of GIS to address programs and problems faced by local governments will result in hard gains and savings that can be quantified in terms of time and money, as well as less tangible benefits that positively impact government operations and the welfare of its citizens.

When properly used, GIS can increase the efficiency of local government, contribute to revenue generation, and provide a host of intangible benefits that are meaningful to citizens and that increase the quality of life.

Some of the potential types of benefits include:

- **Productivity gains** by greatly reducing labor and cost in accessing information, integrating multiple data sources, performing complex analyses, and presenting information in map form. Staff efficiency gains with GIS in the range of 20 to 60 percent have been observed in government agencies.

- **Information security and protection against catastrophic loss** of valuable paper maps and records in the event of a fire or other disaster.

- **Avoidance of infrastructure costs** associated with remedial maintenance or duplicative excavation and construction work by using the GIS to better coordinate and plan road and utility maintenance work and avoid high-cost replacement.

- **Support for economic development** by using GIS to help promote targeted industry, screen available sites, and quickly provide maps and information to prospective developers.

- **Improvement in the quality and timeliness of services,** particularly through use of GIS capabilities, often integrated with the Internet, to respond to information requests of citizens and businesses asking questions that are geographically related.

- Positioning to **meet new state and federal regulations, reporting requirements, and criteria for grant approval** that require gathering and processing of geographically related data.[1]

- **Avoiding future costs** by using the GIS for planning and decision making in such areas as planning and designing major capital projects, lowering the potential for risk and loss in natural disasters, more effectively meeting requirements of new state or federal regulations, and many other potentially costly requirements of local governments.

- **Opportunities for outside revenues** by selling GIS data or products, using the GIS to help obtain outside grants, or for joining in partnerships with other organizations in a local area (e.g., private utilities) to help fund GIS implementation.

- **Catalyst for technology advancement and innovation** by stimulating the growth of the private GIS industry in Kentucky and enhances related economic and educational benefits.

- **Enhancing the capabilities and technology awareness** of government personnel to better meet the demands of the public and improve their perception of local government.

1. A prime example is the recently approved reporting standards of the Governmental Accounting Standards board (see GASB Statement No. 34, June 1999), calling for state and local governments to significantly increase inventory and reporting on the value of infrastructure assets.

GIS Database Concepts and Development

Basic Map and GIS Data Concepts

It is convenient to depict a GIS database as a series of map layers as shown previously in Figure 1. These layers store graphic information about map features (parcels, streets, utility lines) and geographic areas (tax neighborhoods, subdivisions, service districts) and are linked to detailed attribute information or descriptions stored in a database. GIS software accesses this integrated graphic and attribute information to support all mapping, geographic query, and analysis applications.

Coordinate Systems and Map Scale

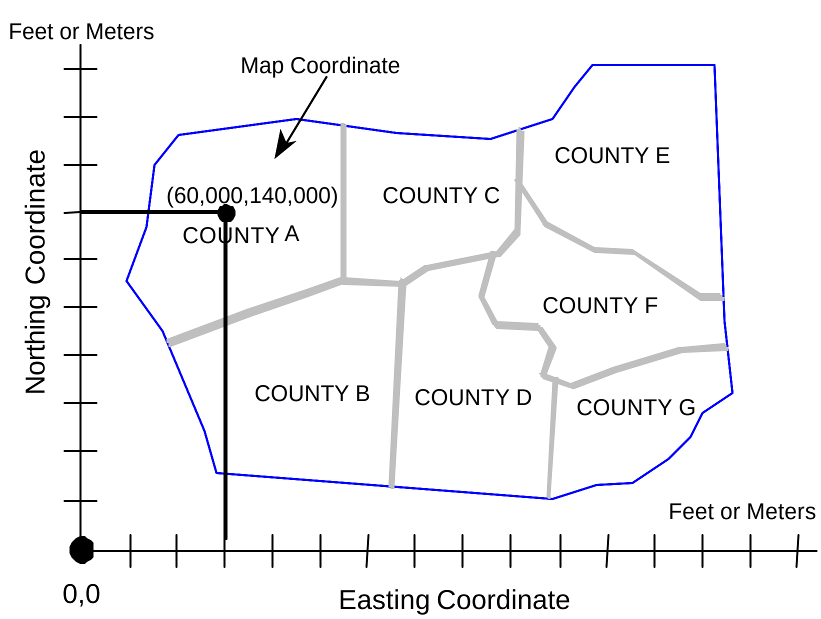
For a GIS to be used most effectively, information needs to be stored in a consistent framework known as a **coordinate system**. It is also important for prospective users to be familiar with the different scale designations that describe map size and level of detail.

Map features and locations in a GIS are referenced to coordinate system map locations in which distances may be measured in a regular grid pattern. The State Plane Coordinate System (SPCS), which Kentucky state agencies and most Kentucky local government agencies use, defines an origin for a specific geographic region or “State Plane Zone,” and all x,y coordinates in the region are then defined from the origin of the zone. Figure 3 illustrates this concept.

Map scale describes the relationship between the size at which features are mapped and their actual size. It is expressed as a relationship between linear distances on the map and corresponding ground distances. Two methods of notating scale are commonly used:

- *Inch-Foot Equivalent*—The scale relationship is expressed as “1 inch = x feet” where the map distance of 1 inch is compared to its corresponding ground distance. For example, topographical quadrangle maps produced by the U.S. Geological Survey (USGS) have a scale of 1 inch (on the map) = 2,000 feet on the ground. Local parcel maps maintained by the PVA typi-

Figure 3: Concept of State Plane Coordinate System



cally have scales ranging from 1 inch = 100 feet to 1 inch = 400 feet.

- *Representative Fraction (RF)*—This is a pure fraction that represents the ratio of map distance to ground distance without specifying any measurement unit. The inch-foot equivalent of 1" = 100' is represented in RF form as 1:1,200 or 1/1,200. For the 1 inch = 2,000 feet USGS quadrangle map, the Representative Fraction is 1:24,000.

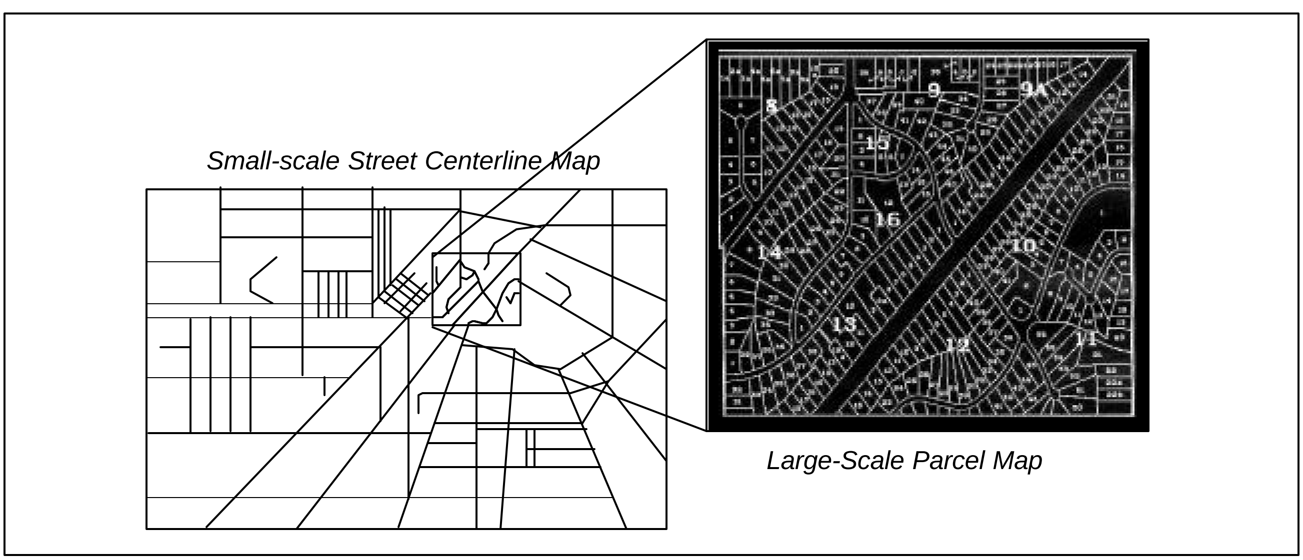
GIS applications use data at a range of scales. “Small-scale” maps (i.e., small Representative Fraction) show large areas with a relatively low level of detail while “large-scale” maps show smaller areas with a higher level of detail (Figure 4). While a GIS can **display or plot** maps at any desired scale, map scale is also related to map accuracy and detail and the scale at which map information is originally **compiled**. The larger the map compilation scale, the higher the level of detail and accuracy that can be included in the GIS database. For instance, field survey compilation techniques gather data for detailed, highly accurate large-scale maps showing property boundaries or plans for construction, while land cover maps prepared from satellite imagery or aerial photographs are typically less accurate and are at a much smaller scale.

Raster and Vector Data

Spatial features in a GIS database are stored in either vector or raster form. A **vector format** represents the location and shape of features and boundaries precisely as a string of x,y coordinates. The precision is limited only by the accuracy and scale of the map compilation process, the resolution of input devices, and the skill of the operator inputting data. In contrast, the grid-based or **raster** format (shown in Figure 5) generalizes map features as cells or pixels in a grid matrix. The fineness of the grid (in other words, the size of the cells in the grid matrix) will determine how accurately original map features are represented.

A GIS uses both vector and raster data. Map layers that need to accurately depict map features, such as manholes, street centerlines, or parcel boundaries, most often use a vector format. Map layers that are stored as images, such as digital aerial orthophotographs, use a raster format. Vector and raster map layers may be overlaid and displayed together in a GIS.

Figure 4: Small-scale vs. Large-scale Maps



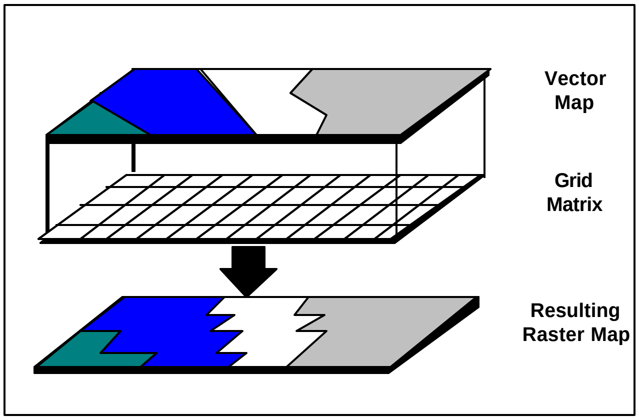


Figure 5: Vector-Raster Relationship

Base Map *vs*. Thematic Data Layers

Data layers in a GIS database may be categorized as "base map" or "thematic." **Base map layers** are those that contain map features that are commonly needed for most applications and which serve as a foundation and reference for other map layers. Figure 6 shows the same location as four different types of base map layers—a planimetric map, a parcel map, an orthoimage, and a street/road centerline map.

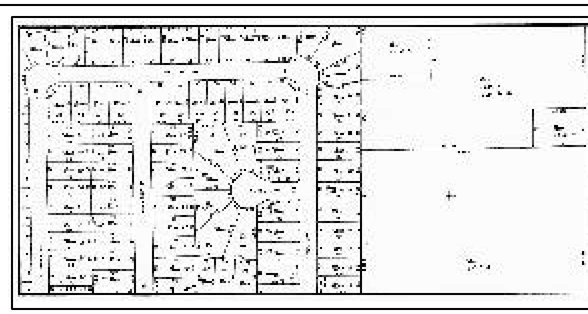
Thematic data layers contain other map features, normally displayed with base maps, that are needed for specific applications. Thematic layers may include such features and information as water or sewer networks, zoning, flood zones, demographic variables such as population density, or land use.

GIS and External Data Integration

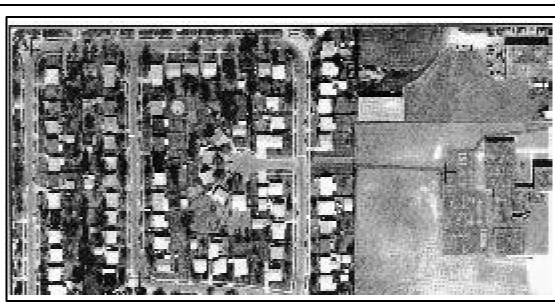
A powerful feature of a GIS is its ability to access information stored in other formats and on other computer systems. For instance, GIS applications may access databases storing building permit records, utility billing data, inspection information, real estate data, and any information that has some locational reference (e.g., an address, a parcel, a facility ID, or an x,y coordinate).

Figure 6: Typical Base Map Layers

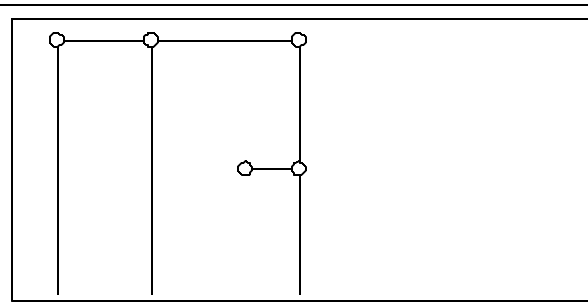
Planimetric Base Map (pavement lines and physical structures)



Parcel Base Map (legal lots and street rights-of-way)



Orthoimage Base Map (aerial image of the earth's surface)



Street Centerline Base Map

GIS applications can also access records or documents that are referenced to locations. As shown in Figure 7, the GIS may be used as a map-based interface to retrieve and display documents, site photographs, detailed engineering drawings, data forms, and other types of records.

GIS Database Capture Approaches and Issues

One of the main steps in implementing a GIS is capturing map and attribute data in digital form. This data capture is normally the most time-consuming and expensive part of GIS development because it usually means converting maps and records from hard copy versions to a form that can be incorporated into the GIS database. The specific method used to automate map data depends primarily on the type of data and the format and condition of source material. Table 2 summarizes the conversion methods that are available, the types of source material that each method uses, and the kinds of layers that each produces.

GIS Data Issues and Decisions

Building a GIS database will rely to the greatest extent possible on map and attribute information that already exists in automated form. In most cases, however, GIS applications will require that additional data be automated from hard copy sources and that data existing in automated form be updated. Major questions and decisions in GIS database design and development are listed in Table 3.

Figure 7: Multimedia Access

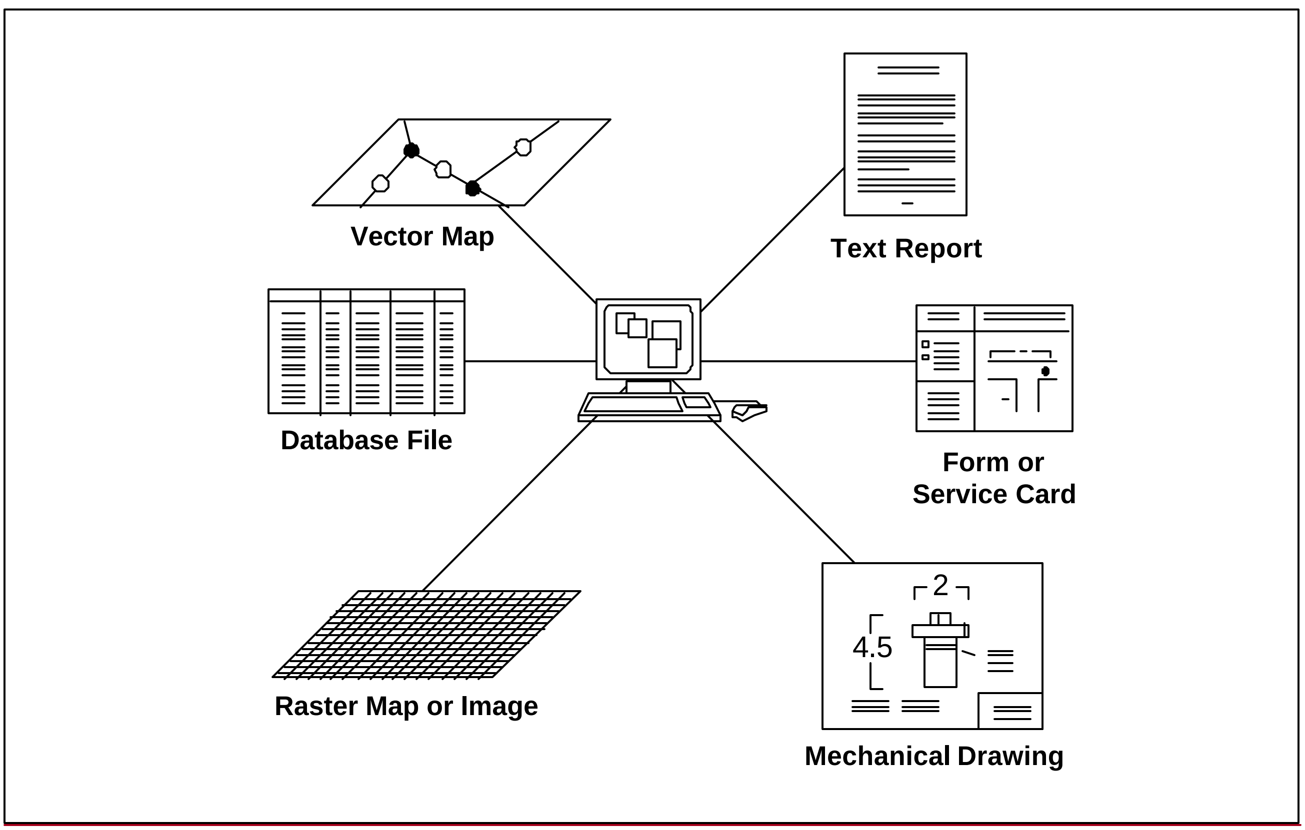


Table 2: Overview of Data Conversion Methods

Method	GIS Layer(s) Produced	Source Material
Photogrammetric Compilation Uses specialized equipment (a stereoplotter) allowing a technician to compile a base map by delineating the locations of roads, buildings, topography, and other features from aerial photography.	Planimetric/Topographic Base Map (surface structures and elevation contours) and street centerlines	Aerial photography and survey control data
Map Digitizing An operator traces features from a hard-copy map, which is mounted on an electronic tablet, and key punches database attribute information about each feature.	Any GIS layer that is compiled from an existing hard-copy map (e.g., property parcels, zoning, utility lines)	Hard-copy map source
Coordinate Geometry Entry Entry of detailed survey information collected in the field in the form of measured distances and compass bearings to delineate boundaries and feature locations.	Parcels or other map features surveyed in the field	Field survey data
Map Scanning and Heads-up Digitizing Hard copy maps may be optically scanned to create a digital image of map features in raster form. With the image displayed on a computer screen, an operator delineates features from the image with the mouse. Features may also be captured from digital orthophoto images.	Any GIS layer that is compiled from an existing hard copy map or a digital ortho image (e.g., property parcels, utility lines, street centerlines, planimetric features)	Digital image from scanned source
Field Data Inventory Global Positioning System (GPS) compact units are typically used in the field to capture accurate locations and enter attribute data. The data can then be uploaded directly to the GIS database on an office computer.	Typically used to map physical features like manholes, traffic signs, etc.	Locations and data captured directly in the field and uploaded to a GIS database
Import of Existing Automated Data In some cases, GIS data suitable for use may already exist in automated form. Attribute data stored in an existing database (e.g., road inventory data on a PC) or map data from another agency (e.g., state or federal agency) can be imported, sometimes with only the need for reformatting, into the GIS.	Attribute data associated with a GIS layer (e.g., parcels), street centerlines, digital orthoimagery	Existing automated data files, usually from a government agency or a private data reseller

Table 3: Database Design Questions

Question	Comment
What type of base map layers are needed to support my GIS?	It is advisable to have, at a minimum, three layers: • A street centerline base map coded with address ranges • An orthoimage layer that can visually enhance the database • A parcel layer to provide a foundation for property-related applications.
What level of accuracy and detail do I need?	There is no simple answer to this question. It is not a goal of the GIS to provide “survey-level accuracy” that can support civil engineering design or legal property transactions. There are, however, some guidelines that can be followed: • At a minimum, an orthoimage should have a resolution of 3 feet (1 meter) or less to be effective for local applications, but in densely developed areas, a resolution of 1 foot is more acceptable. • Street centerlines, parcels, and utility lines should be mapped so that their coordinates are within at least 10 to 20 feet of their true locations. Map accuracy levels at the 5-foot level are more desirable for densely developed areas.
How do I update my GIS database after it is compiled?	Approaches to map updating depend on the specific layer and how frequently conditions change. Updating of street centerline and parcel layers is often done from new subdivision plats or deeds. GIS applications guide the user through steps to digitize new streets and parcels. Utility layers and planimetric base layers may be updated from “as-built” engineering drawings, which, if they are available, show actual construction. It is most efficient to set up a process to import digital plats and engineering drawings (from CAD systems like AutoCAD) directly into the GIS to reduce the amount of manual work involved.
Should I establish a regular update schedule?	It is very important to set up procedures and GIS applications to support database update for those layers that undergo change. Ideally it is best to make those updates soon after changes occur (e.g., after a new subdivision plat has been approved), but updating using well-designed GIS applications may be done on a period basis if appropriate.

Sources of GIS Data

As previously mentioned, it is often more cost-effective to import and use existing data for the GIS whenever acceptable data is available. In Kentucky, several state agencies have compiled GIS data which is usable by local governments. While this data does not generally provide a level of accuracy and detail to support very precise mapping and analysis, it can be used as a basis for initial GIS implementation at a reasonable entry cost. Table 4 on the following page provides a summary of some of these data. For download links to most of the data sources that are listed, users should first visit the DATA page at the Kentucky Office of Geographic Information’s Web site (http://ogis.state.ky.us) or contact the individual agency listed as the source of the data or the Kentucky Office of Geographic Information (OGI) for more information.

Table 4: Kentucky State and Federal Agency GIS Data Available

GIS Data Layer or Category	Name and Source*	Access Format	Comments
General Planimetric Base Map	Digital Raster Graphics (DRG) Source: USGS/Kentucky OGI	Internet download or CD-ROM purchase http://ogis.state.ky.us	Digital scanned versions of USGS quadrangle maps providing a raster image of the general road network and other physical features. From 5 to 25 years out of date for most areas of Kentucky.
Orthoimagery	Digital Orthophoto Quarter Quadrangles (DOQQ) Source: USGS/Kentucky OGI	Internet download in MrSID format or reduced resolution TIFF format, or CD-ROM purchase in compressed or uncompressed format and as a county. MrSID mosaic (county CD ROM includes DRG files) http://ogis.state.ky.us	Geographically registered images each covering one-quarter of a USGS quadrangle with a resolution of about 3 feet.
Street/Road Centerlines	Transportation Cabinet Road Database Source: KY Transportation Cabinet	Internet download http://ogis.state.ky.us	Single seamless state image of county files with road centerlines coded with route numbers (no address ranges). Some local streets and roads are missing. Accuracy about 5 to 40 feet.
Water and Sewer Service Areas	Kentucky Water Resource Information System Source: Kentucky Infrastrucure Authority	Internet download http://kymartian.state.ky.us/wrdc/mapgis/maps.htm	These statewide data sets provide the water supply and wastewater collection and treatment service area that were developed for the 1999 state water resources plan.
Water and Sewer Lines	Kentucky Water Resource Information System Source: Kentucky Infrastructure Authority	Internet download http://kymartian.state.ky.us/wrdc/mapgis/maps.htm	These statewide data sets provide the water supply and wastewater collection and treatment service area that were developed for the 1999 state water resources plan.
Demographic Data	U.S. Census Bureau Data Source: U.S. Census Bureau	Internet download of Census TIGER files http://www.census.gov	Population statistics (age, income, etc.) aggregated by block group. Now available from 1990 Census and thus not up-to-date. Estimated to be available in 2001 for 2000 Census.
Administrative Boundaries	City and County Points and Boundaries Source: Kentucky Infrastructure Authority	Internet download http://kymartian.state.ky.us/wrdc/mapgis/maps.htm	The Department for Local Government maintains information on place locations and the official boundaries of the state's political subdivisions.
Hydrography	Digital Line Graphics (DLG) and Digital Elevation Models (DEM) Source: USGS/Kentucky OGI	Internet download http://ogis.state.ky.us	The new National Hydrography Dataset (NHD) should be available for all 120 counties by mid-2001.
Geologic Data	State Geology Series Source: Kentucky Geological Survey	Internet download http://www.uky.edu/KGS/gis/kgs_gis.html	These data series include a variety of geologic features, e.g., fault lines, oil and gas wells, etc.
Soils Data	STATSGO/SSURGO Source: USDA Natural Resources Conservation Service	Internet download or CD-ROM purchase http://www.ftw.nrcs.usda.gov/ssur_data.html	The STATSGO soils data provides generalized associations in three GIS formats. More detailed series-level data in the SSURGO database is now available for 31 counties, with the whole state to be completed in the future.
Land Cover	National Land Cover Data Set Source: U.S. Geological Survey	Internet download or CD-ROM purchase http://ogis.state.ky.us	This approximately 23 MB data set provides the most up-to-date land cover map for the entire state. The cost of the CD-ROM is $25.00.
FEMA Floodplain	Digital Q3 Flood Data Source: Federal Emergency Management Agency	CD-ROM purchase http://www.fema.gov/msc/q3flooda.htm	Available for 98 counties. Visit FEMA's Web site to determine county availability and purchase CD-ROM for $50.00.
Select Environmental Resources	Geospatial Data Library Source: Various	Contact KNREPC http://www.nr.state.ky.us/nrepc/ois/gis/products.htm	These data sets include the National Wetlands Inventory (NWI), Superfund sites, etc.

*For source contact information, please refer to Appendix A.

In addition to data available from the Commonwealth's state agencies and several federal agencies, a number of private businesses sell GIS data for general use. While purchasing commercial data sets can be expensive, it provides an immediate way to obtain data that can be used by the GIS. Several of the more commonly used commercial data sources are provided in Table 5.

Table 5: Examples of Commercial Data Sets Available for Purchase

Name and Source	GIS Data Layer or Category	Access Format	Comments
Highway and Street Centerlines, Addresses, Public Institutions, Recreation Areas, Zip Codes/ Water Features, Landmarks	DynaMap 2000 Source: Geographic Data Technology, Inc.	CD-ROM	The product is available in a variety of software formats. Purchasers buy the data files for the entire state on one CD-ROM.
Highway and Street Centerlines, Addresses, Public Institutions, Zip Codes, Water Features, Landmarks	EtakMap Source: Etak, Inc.	CD-ROM or 3.5 inch diskette	Many databases are updated quarterly.
Individual Businesses, Business Patterns, Workplace Populations, Demographics	Source: Claritas	Internet download or CD-ROM purchase	
Health Data and Statistics	Source: Health Demographics	CD-ROM	
Consumer Facts, Business Forecasts, Demographics, Traffic Counts	Source: National Decision Systems	CD-ROM	
Economic and Demographic Projections	Source: Woods & Poole Economics	CD-ROM	Available at the county level

Additional sources of commercially available data can be found in the listing of GIS magazines and other references provided in Appendix A. Most GIS software vendors list data sources on their Web sites.

Computer Hardware and Software

Computer Hardware Components and Networks Supporting GIS

Computer Hardware Components

Today, the GIS makes use of the same standard PC computer devices that support common office applications. Often these office systems include multiple personal computer workstations on a network that access data and software stored on a computer server. Because a GIS is dependent on the display and plotting of maps, there is often a need to acquire some additional hardware, including large-format plotters and larger-monitors for selected users. In cases where in-house map conversion is being carried out, it may also be necessary to acquire scanning devices for imaging hard copy maps and documents.

> The GIS will make use of standard hardware devices (PC workstations, servers, printers) that are already in use for basic office automation tasks. GIS may require some upgrades to existing hardware and purchase of a large-format plotter.

Table 6 provides a summary of the main types of computer devices that could be part of a GIS.

For the most part, a GIS will operate in a Microsoft Windows environment using servers and PCs running Windows95, Windows98, or Windows NT operating systems. The Kentucky Governor's Office for Technology (GOT) has prepared computer system acquisition guidelines for state agencies, which are also generally applicable to local governments. Local governments in Kentucky are also eligible to purchase computer hardware through the state's fixed price purchase contracts. More information on Kentucky's computer standards can be obtained by accessing the GOT site at www.state.ky.us/kirm/arch_toc.htm.

Computer Networks

Computer systems supporting GIS (and other automated applications) may range from single or multiple computers operating in a non-networked "stand-alone" mode to multiple computers and peripheral devices (e.g., printers or plotters) connected on a network through a cable supporting data transmission. While it is possible to operate a GIS with individual, unconnected computers, it is usually more advantageous to operate with a computer network—particularly when there will be multiple users, in different office locations, that need to access the system. Computer networks have the advantage over stand-alone systems because access to a central database makes operations more efficient, avoiding the need to redundantly store data at multiple workstations, and giving options for access security and data backup.

Computer networks used for GIS and most office automation applications store data and software on a computer server. A server is a computer specially designed to centrally store and manage large amounts of data and to provide access to this data and certain software to users from their PC workstations (sometimes called "clients"). This type of network is sometimes referred to as a "client-server network" as depicted in Figure 8.

As also shown in Figure 8, one or more servers, PC workstations, and "peripheral devices" (e.g., plotters, scanners) that are connected by cable can communicate together on the network.

It is also possible to set up links to systems external to the GIS network. As Figure 8 also shows, it is feasible to access data on other systems (e.g., a mainframe or minicomputer where geographic data may reside) or to get access to the Internet.

Table 6: Summary of Computer Devices

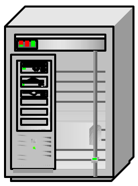
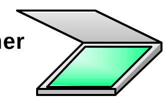
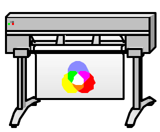
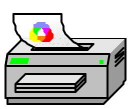
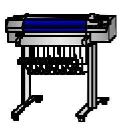
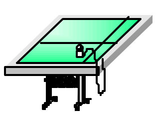
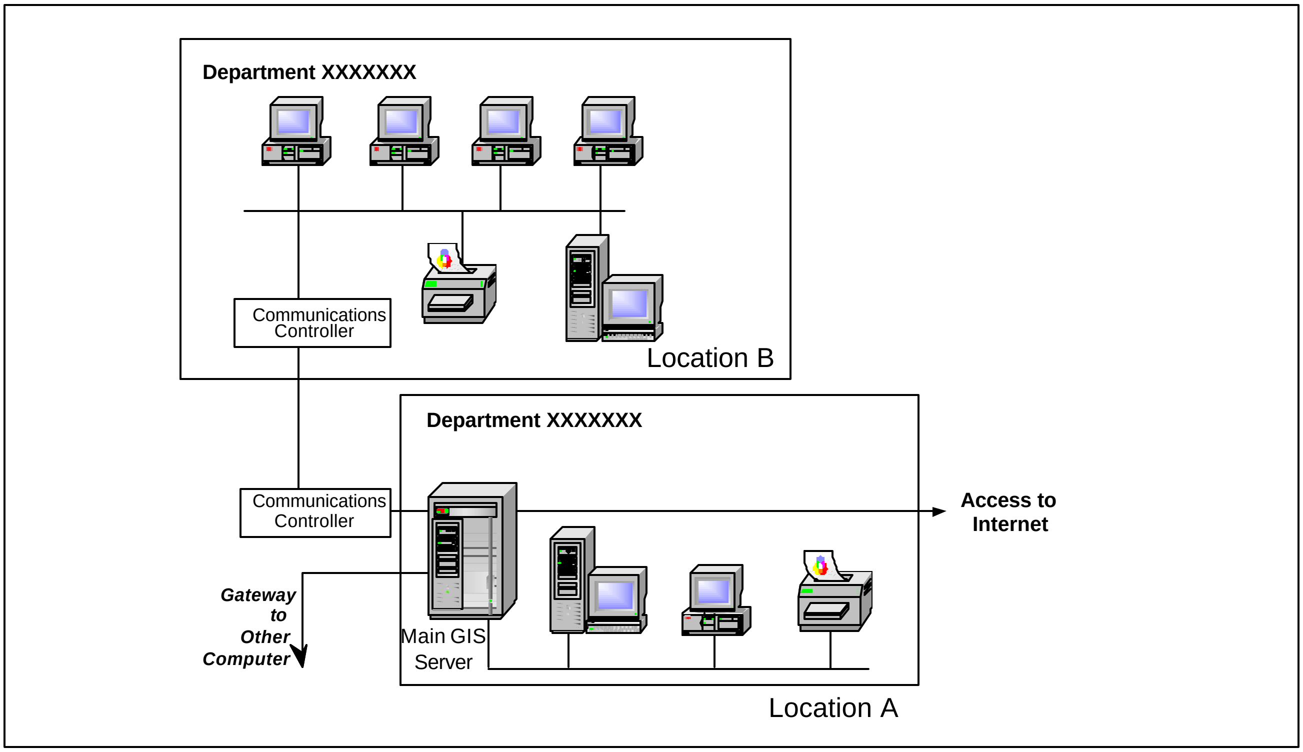
Device Name and Price Range	Function	Basic Specifications
GIS Server ($7,000-40,000) 	Supports central database and access to users. Also provides computing resource to support query and display operations from PCs.	Servers often with multi-processors (up to 4 processors) at 500MHz speed (or higher), main memory capacity of up to 1GB configured initially with at least 512MB, at least 100GB mass storage upgradeable to at least 40GB, cartridge tape drive, CD-ROM drive at 40X speed or greater; Windows NT or UNIX operating system.
GIS Workstation ($2,500-4,000) 	Full function PC configured for full graphics and GIS functionality with considerable local processing. Capability to support all GIS applications.	Based on chip speed of 500 MHz or greater; 256 megabytes main memory upgradeable to at least 512MB; 19" monitor or larger; at least 20GB mass storage; CD ROM drive at 40X speed; Windows NT.
Small-format Desktop Scanner ($250-600) 	For scanning of documents, small format map sources, and photos for entry into a document database.	Pass-through scanner; accommodate 11" x 17"; B&W, gray-tone, or color; selectable resolution from 200 to 1,000 dots per inch; top speed of at least 30 pages per minute (B&W mode).
Large-format Scanner ($3,000-10,000) 	For scanning large maps, engineering drawings, aerial photographs, or large documents for entry into a document database or for use as a basis for heads-up map conversion.	Pass-through scanner; up to 36" width; B&W or gray-tone; selectable resolution from 200 to 1,000 dots per inch. Includes software for basic post-processing (e.g., rotation, cropping, speckle removal).
Small-format Color Printer ($1,000-3,000) 	For production of page-size plots as color proofing for larger-format color plots, for use in reports, or for preparation of presentation materials (overhead transparencies).	Inkjet plotter with up to 600 dots per inch resolution; capable of 11" x 17" format. Speed of at least 3 pages per minute, but greater speed is preferable (laser recommended).
Large-format Color Raster Plotter ($5,000-11,000) 	For production of large-format maps (color or B&W) for standard map production or large wall map production.	Inkjet plotter at 400 to 800 dots per inch resolution, 36" width plotting, local memory buffer, and plot rasterizing software.
Large-format Digitizing Tablet ($1,500-3,000) 	Used for direct trace digitizing from hard copy map sources when other input methods are not appropriate.	24" x 36" active area.
Pen-based Portable Computer ($1,000-2,000) 	Designed for use in the field with entry via keypad or by pen. Used to support field data collection, facility inspection and maintenance, and other field-based GIS applications.	Based on chip speed of 266 MHz or faster, 64MB main memory, 3GB mass storage, keyboard, and pen controls. May use Windows 98, NT, or Windows CE operating system.

Figure 8: Client-Server Network



GIS Software

GIS capabilities are provided in commercial software packages. Like other computer software packages, a GIS software package gives users a core set of functions that can be accessed and applied to meet their specific needs. A GIS software package is like a tool box. Users must use the software tools, along with the GIS data, to generate results (a hard copy map, a report, a screen display).

Commercial GIS software packages provide a complete set of functions for mapping, database query, and spatial analysis. While these packages provide a standard user interface, the interface can be customized to adapt to users' needs.

A GIS software package from a commercial company like ESRI, MapInfo, or Intergraph usually is closely integrated with a database management software package like Oracle or Microsoft Access. The GIS and database management package function together as shown in Figure 9 to support all users' needs for mapping, geographic queries, or analysis.

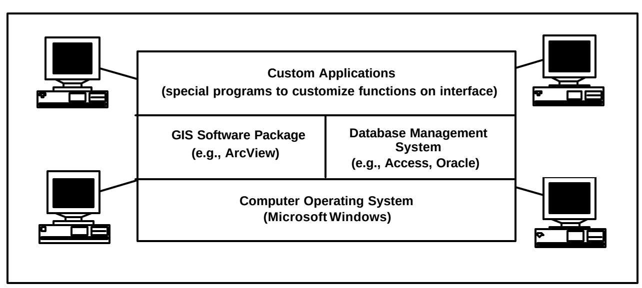


Figure 9: GIS Functionality Integrated with RDBMS

Table 7 provides a summary of the main software features in a GIS. These are the basic tools that can be used to build user applications.

It is a computing standard for state government in Kentucky to use GIS software from the Environmental Systems Research Institute (ESRI), a California-based GIS company. ESRI provides a number of software packages, including ArcInfo and ArcView, that are widely used in Kentucky. The State of Kentucky Governor's Office for Technology has prepared software acquisition guidelines for state agencies which are also generally applicable to local governments. Local governments in Kentucky are eligible to purchase GIS and other software through the state's fixed price purchase contracts. More information on Kentucky's computer standards can be obtained by accessing the GOT Web site at www.state.ky.us/kirm/arcstd.htm.

Examples of GIS Applications

The set of functions available in GIS software is used for specific applications. Sometimes these are simple applications (e.g., display a map of parcels for a specific area with owner name shown), and, at other times, the applications are more complex. Users can perform simple applications by interactive menu commands that are standard for the software package (see Figure 10). More complex applications may require the development of custom screen menus, specially designed map displays, or other programming to easily perform complex operations. While some applications will require up-front custom development, they may be accessed over and over by users once the applications are designed and developed. The objective, of course, is to provide easy-to-use, intuitive applications that allow users to perform GIS operations with a minimum of training or need for reference documentation.

> GIS software and data can be used for a limitless number of applications. An application is a specific use of the GIS that supports update of maps, generation of maps, special queries and map display, geographic analysis, or access to external data sources.

Many cities and counties, large and small, in North America and in Kentucky have put in place operational GIS programs that have delivered real benefits for their users. Some illustrations of municipal and county GIS applications are presented in Figures 11 through 20.

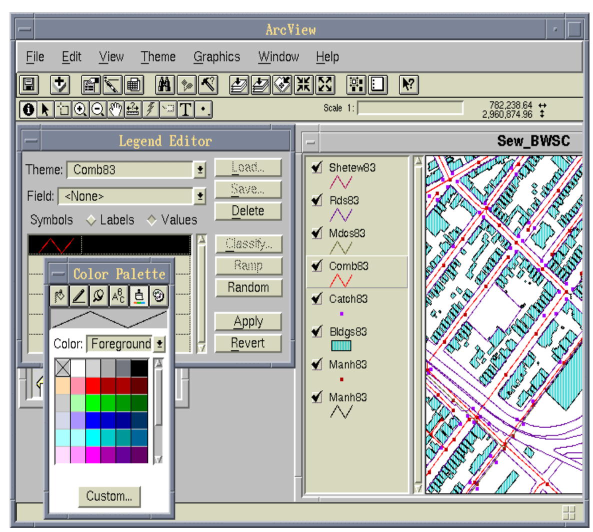


Figure 10: Interactive Menu Commands

Table 7: Summary of Software Features

Core GIS Software Capabilities	Explanation
Geographic Data Management	Database administration tools for managing data access by users, locking of data during edit, and maintenance of metadata.
Tabular Attribute Data Management	Software environment and capabilities for storing and managing database attributes linked to map features in the GIS database. May involve use of a vendor-proprietary system for attribute storage or a commercial relational database management package.
GIS Data Import/Export Utilities	Utility programs bundled with the GIS package for translation of GIS or CAD data to or from another format, including industry-standard formats like DXF, SIF, DLG, or SDTS.
GIS Data Capture and Editing	A range of interactive and batch processing functions for entry of map data through such means as board digitizing, coordinate geometry entry (COGO), scanning, and heads-up digitizing, along with capabilities for editing GIS data, performing error checking and resolution, map rectification, and transformation of coordinate systems and map projections.
Map Design and Composition	Interactive capabilities for the design of map plots and displays, automatic creation of thematic maps and legends, and modifying map symbology and annotation for custom map displays.
Basic Geographic Query and Display	Basic tools for performing attribute or map-based queries, including display of attributes for a selected map feature or identification of map features that satisfy selected database criteria. This category also includes tools to create special thematic maps where areas or linear features are shaded based on their attribute values or classification.
Address Matching/Incident Matching	Automatic mapping of point features from an imported file with site addresses through an interpolation along a street segment coded with address ranges (right and left side of street). Locations are mapped as point symbols with designated offset and user-defined symbols.
Tabular Report Design and Production	Allows users to design tabular reports from GIS data or derived from GIS applications.
Spatial Analysis	Includes a range of analysis tools, such as basic map measurements (area and distance), buffer analysis, polygon overlay analysis, and other spatial processing.
Network Analysis	Spatial analysis operations based on linear networks (e.g., road or pipeline systems), including such operations as “shortest path tracing” and “region allocation.” Network analysis capabilities in GIS packages often allow users to design network models based on attributes of network segments.
Terrain and 3-D Data Processing and Analysis	Capabilities for storing three-dimensional data normally in a grid or triangular integrated network (TIN) format with functions for 3-D analysis such as contour mapping, 3-D display, draping of map features over a 3-D display, slope and aspect analysis, etc.
Raster Image Processing Capabilities	Capabilities for the manipulation and processing of raster images (e.g., digital aerial photos or orthophotography, satellite images), including functions for the import and rectification of raw imagery, digital image enhancement, and automated classification of multi-spectral imagery.
Application Development Tools	Programming environment for customizing applications accessing software functions provided by the package, including proprietary languages included with the GIS software package or industry-standard tools (e.g., C++, Visual Basic, Delphi) that may be used for application development.

Examples of GIS Applications

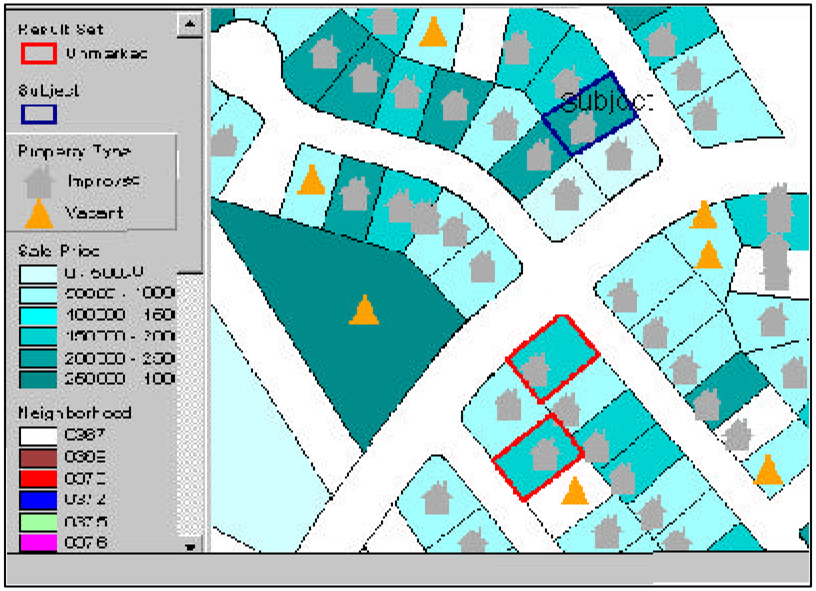


Figure 11: Query and Analysis of Property Sales Prices

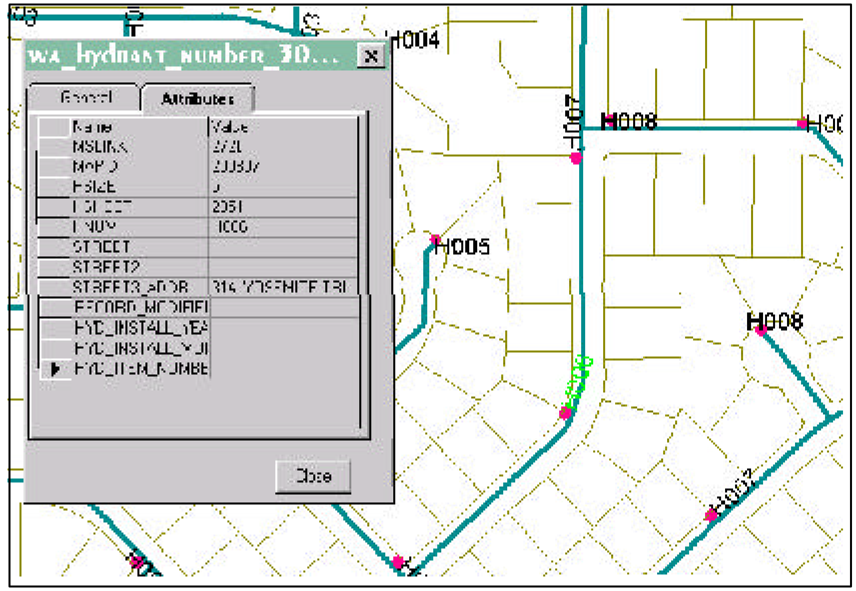


Figure 12: Tracking Hydrant Inspections and Maintenance

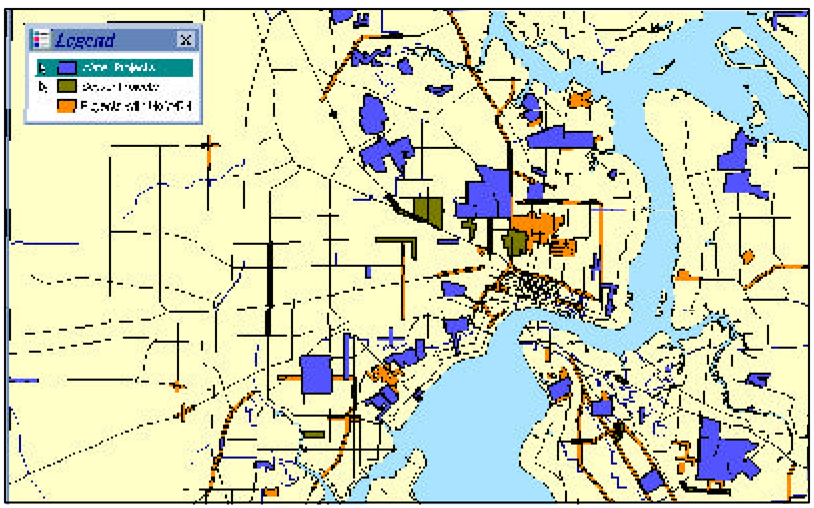


Figure 13: Land Development Status Tracking

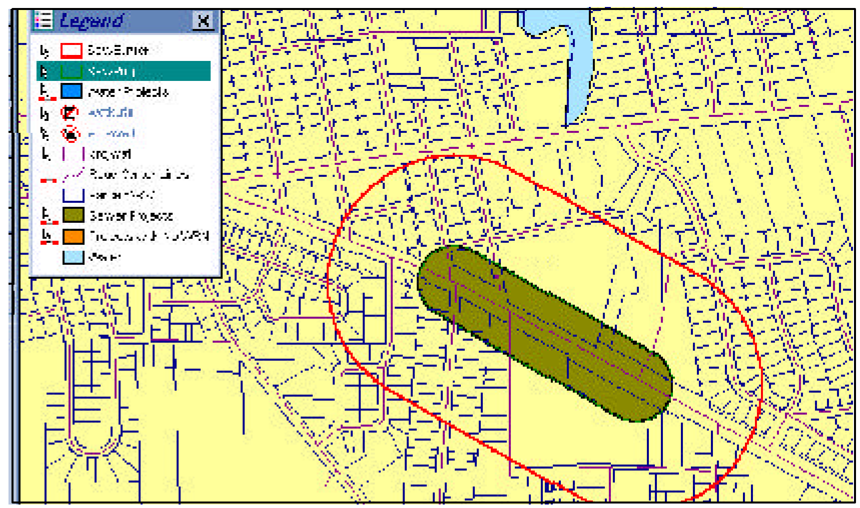


Figure 14: Identification and Notification of Property Owners Near Road Project

Examples of GIS Applications

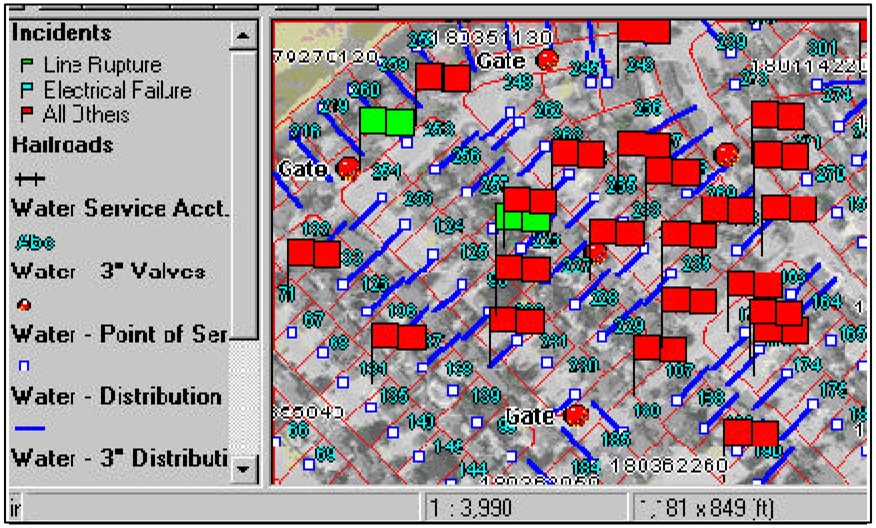


Figure 15: Display and Tracking of Citizen Calls

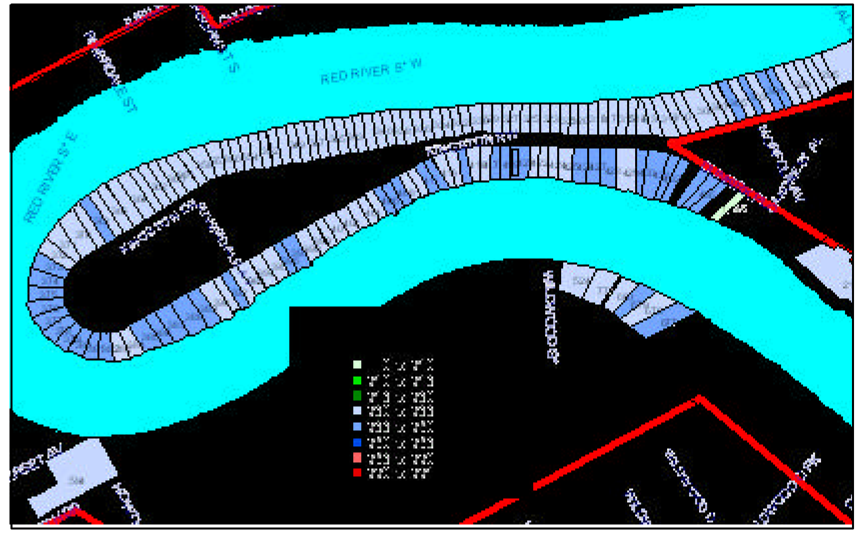


Figure 16: Flood Damage Risk Assessment

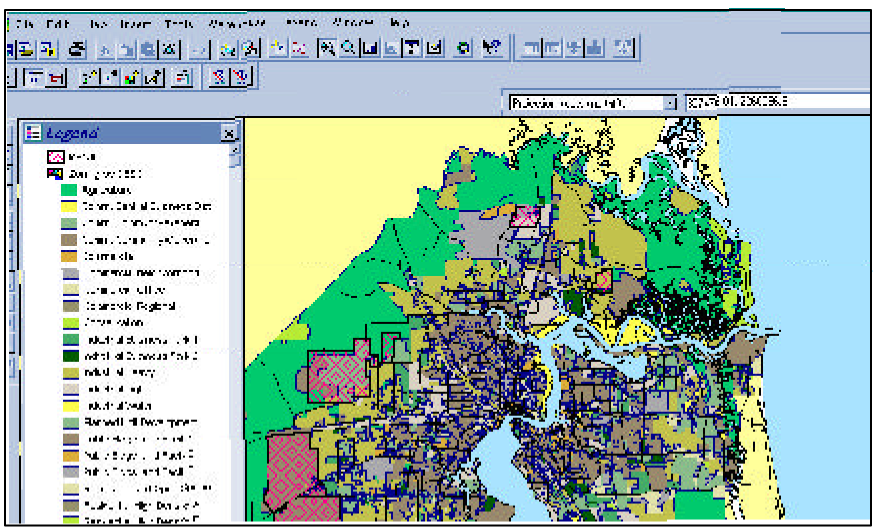


Figure 17: Economic Development Site Selection

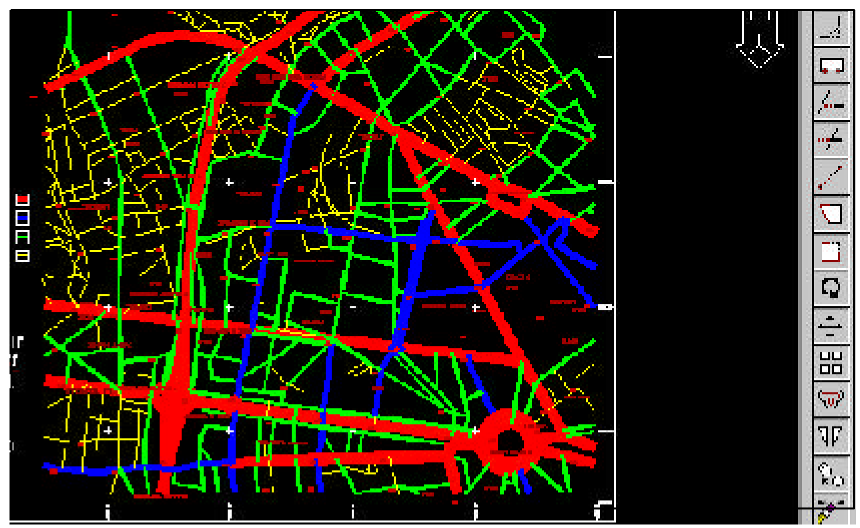


Figure 18: Traffic Volume Analysis

Examples of GIS Applications

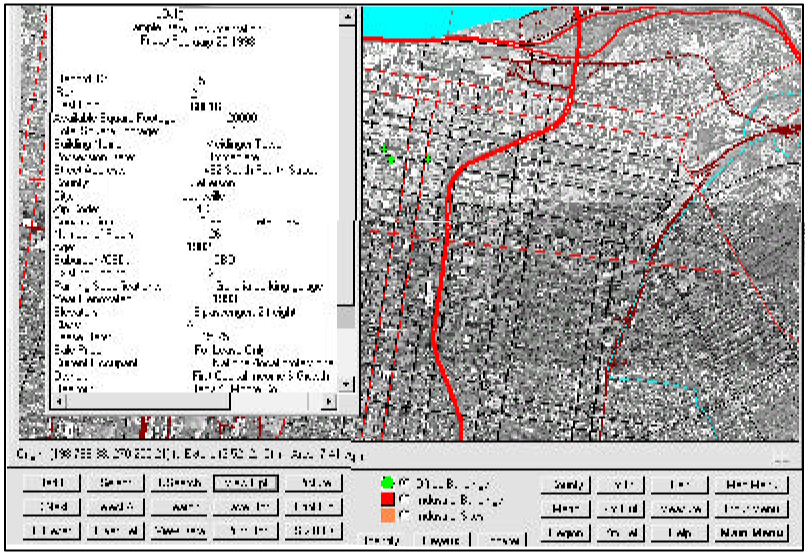


Figure 19: Access and Display of Property Information

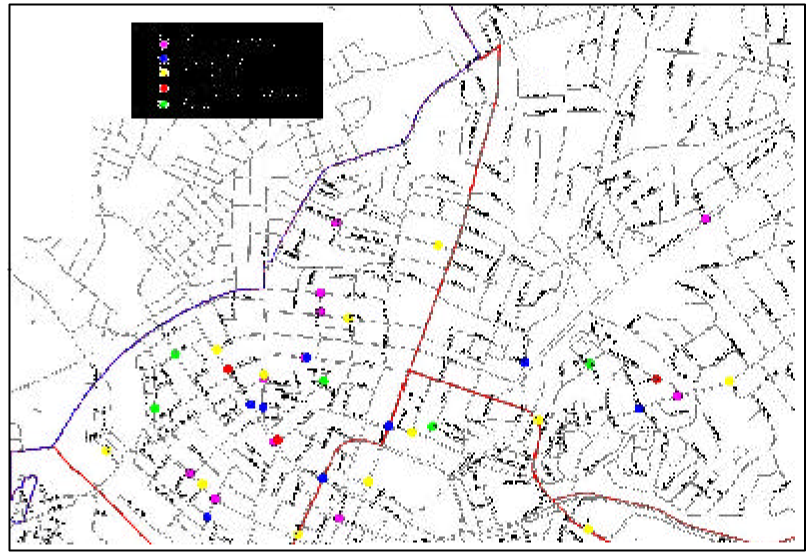


Figure 20: Mapping and Analysis of Crime Incidents

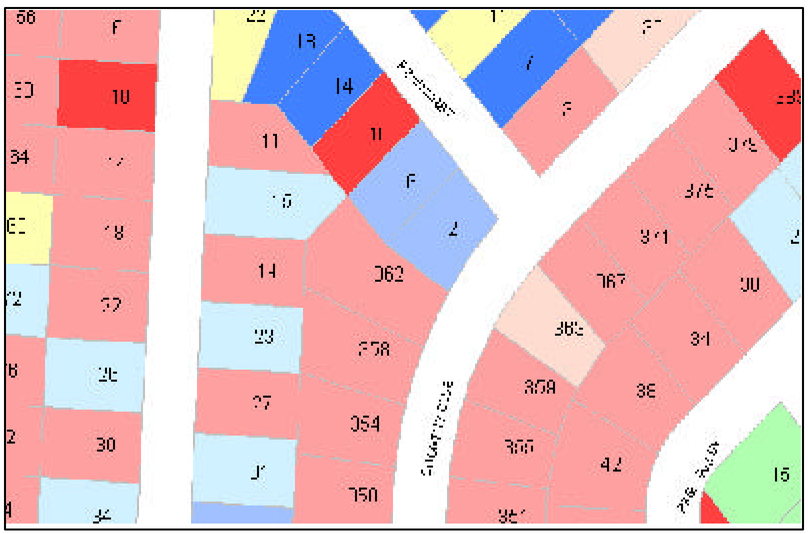


Figure 21: Thematic Map Display of Parcels Based on Property Values

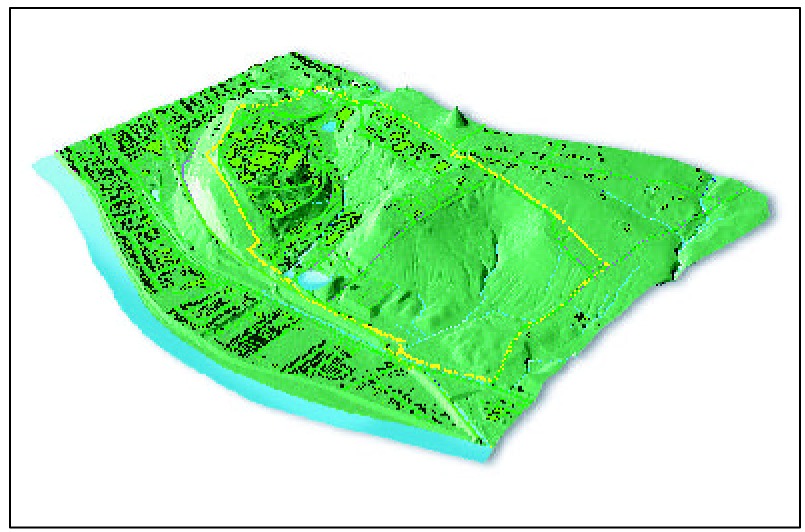


Figure 22: Three-Dimensional View Using Digital Elevation Data with Map Overlay

GIS Hardware and Software Issues and Decisions

Individuals and governments new to GIS often ask some typical questions about the technology and what its introduction will mean for their organizations. While the following list is not all inclusive, it does cover a number of frequently raised concerns.

Table 8: Hardware/Software Questions

Question/Issue	Comment
1. Can I use my existing PCs or do I need to upgrade?	For most GIS applications, it is important to have PCs that run at a speed of at least 200 MHz and have at least 96MB of memory. Also, PCs should have at least a 17" color monitor. Most users find that faster PCs (300 MHz speed or greater) with 128 MB memory are more responsive, and for frequent users, 19-inch color monitors are preferred. Some upgrades or new acquisitions may therefore be necessary.
2. Do I need a server and a network connecting all my devices?	It is not absolutely essential to have a server or a network. It is possible to have a stand-alone system in which a small number of users in a single office use non-connected PCs and share data through diskettes or CDs. A network is recommended, however, because of the enhanced flexibility it provides. It can be a simple “peer-to-peer network” with no server but which allows individual PCs to share files or one PC on a network which can also be designated as a server. When more that about six people need to share data, it is usually important to install a separate computer server.
3. What type of plotters do I need?	Maps from the GIS may be produced on devices that range from page size (low cost B&W laser printers) to large-format color plotters. GIS applications may make use of all types of devices depending on the specific need. It is advisable to have at least one B&W laser printer, one page-size laser color printer, and preferably, one large-format laser color printer/plotter (36" width). If the cost for one of these large-format devices (about $6,000) cannot be justified, there should be one medium format color laser printer (C-sized for maximum plotting at 14" x 17" for about $1,500).
4. What GIS software should I use?	Several national companies offer core GIS software. Software packages from ESRI are very popular in Kentucky, and selection of one or more of these products has the advantages of an existing user base in other government agencies, in-state training opportunities, and some existing custom applications. ESRI’s ArcView package is recommended for entry-level use, but the MapObjects and ArcInfo products are suitable as well, particularly for more technically advanced users. ESRI’s ArcIMS software may be used for applications on the Internet.
5. What should be the role of the Internet in the GIS?	GIS applications can be developed for access via the Internet or your organization’s intranet, if one exists. This is an option, particularly if you are already building other non-GIS applications on the Internet and see access to the system through Internet browsers to be in your interest. This would require an Internet Web server with adequate security.

GIS Implementation and Deployment

Implementation Approach

Implementing a GIS in city or county government can be a complex and time-consuming undertaking. It is usually carried out in phases which typically include the major steps shown in Figure 22.

After having made a decision to explore GIS implementation, a needs assessment carried out by internal staff or with the help of an independent consultant should be conducted. The purpose of the assessment would be to examine current operations and identify GIS applications and their priority. The definition of applications forms the foundation for the subsequent GIS design and development.

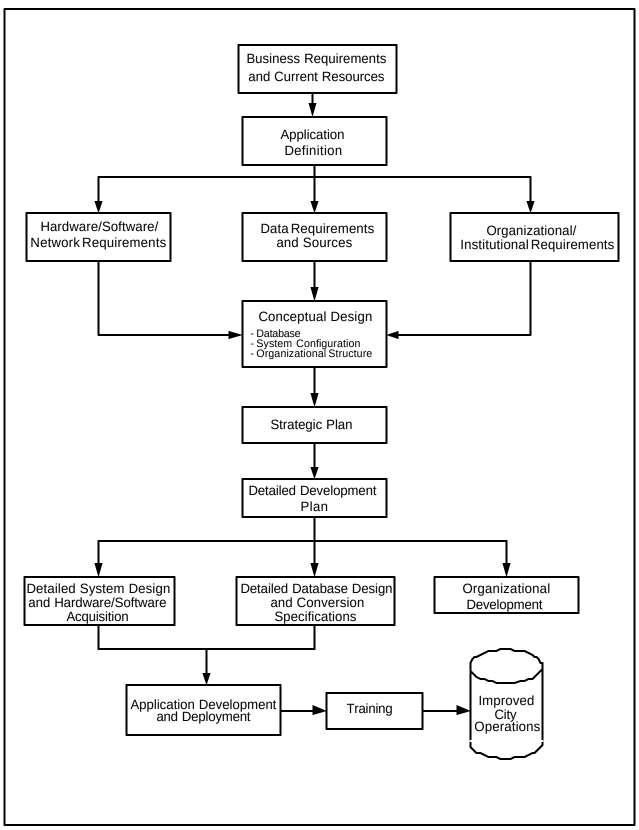


Figure 23: Implementation Phases

A good GIS implementation strategy is to choose a small number of high-priority projects to pursue based on the community's top priority needs. Then, complete those projects quickly so that decision-makers and the citizens can actually see the results.

Frequent Questions and Practical Pointers Guiding GIS Implementation

Some typical concerns and questions about the organizational and financial aspects of GIS implementation are presented below.

GIS has a 20-year history in local governments in North America. In that time, the technology has improved and users have learned many lessons about how best to adopt and deploy GIS effectively. Cities and counties that are implementing GIS for the first time can benefit from the experience gained by others. Some of the key lessons gained from this experience are summarized below:

1. Developing the underlying data is the most expensive part of establishing a GIS. It frequently represents 75 to 80 percent of an agency's total outlay for GIS plus ongoing maintenance of the data.

2. It usually takes three years before most government agencies experience cost savings and benefits that exceed their initial investment cost. The payback period can be longer or shorter depending on system complexity, existing hardware and network conditions, and the amount of implementation work that can be done in-house.

3. Finding initial funding to start a GIS is challenging but not impossible. While the Commonwealth of Kentucky does not have grant funds specifically earmarked to help local governments implement GIS, some federal grant programs can provide a portion of the required

funds. In addition, a few software vendors periodically provide start-up grant assistance, and some GIS consulting firms will help identify public and private funding sources and may even provide front-end financing with multi-year repayment agreements.

4. Kentucky law allows certain GIS products to be sold to customers. However, selling products requires a clear rationale or basis for setting the charges. In addition, it is important to make sure that customers sign a license agreement prohibiting the resale of the products.

5. The personnel involved in GIS require frequent training to keep up with advances in the technology. Any effort to establish a GIS must include funds for ongoing staff training as part of the annual operating budget.

6. Many smaller individual government jurisdictions may be unable to afford GIS implementation, but multiparticipant GIS partnerships involving several agencies or levels of government provide an alternative that lets even the smallest agencies begin to develop GIS capability. While forming a GIS partnership may produce initial delays in implementation, a cooperative effort reduces expenses and effort for each of the participants.

7. A good implementation plan must consider all of the aspects of GIS development, including organization structure and responsibilities, data availability and requirements, hardware and software acquisition and maintenance, and application development.

Target Systems and General Costs

This section describes two general GIS system configuration scenarios that may be used as templates to examine technical and institutional issues and costs for GIS implementation. While these templates do not exactly mirror a particular local government case, they may be used as examples for preliminary planning purposes. Two scenarios are described—1) a low-cost system configuration, and 2) a moderate-cost system configuration. The basic characteristics of these scenarios are compared in Table 9.

Based on the two systems described in Table 9, a typical local government should expect to spend in the range of $40,000 during the first year to build a low-cost introductory GIS. This does not include any cost associated with data capture beyond using the sources that are already available from the state. If a minimal amount of data capture is included, the cost could increase to $80,000.

First year costs for a moderate-size system would likely be about $85,000, exclusive of additional data capture. Assuming the same level of expenditure for data capture as a low-cost system, the first year investment cost would increase to approximately $130,000.

After the initial investment in a GIS, annual costs would include personnel expenditures (including training), the purchase of supplies, licensing charges for software, and data capture or conversion expenses. In addition, an upgrade or replacement plan for hardware and software would need to be devised to ensure that equipment and computer programs stay up-to-date.

The preceding summary review does not include any costs associated with consulting services to perform a needs assessment or design a conceptual GIS database and system. Further, the summary level costs do not contemplate the development of any customized GIS applications and necessitate that the local agencies rely,

Table 9: GIS Configuration Scenarios

	Low Cost Scenario	Moderate-Cost Scenario
General Setting	Small city with under 7,000 population or largely rural county with less than about 15,000 population.	Medium size Kentucky city with population of about 5,000 to 20,000, or a growing county with some urban development and a population of about 12,000 to 30,000.
Number of GIS Users	1 to 5 frequent active users and several other staff that occasionally access the GIS or use products generated from it.	3 to 10 frequent, active users and other staff that occasionally access the GIS or use products generated from it. Opportunities for access to the GIS or use of products by the public.
System Configuration	All users in a single building. Several stand-alone PC workstations OR a simple peer-to-peer network (no server) OR a simple network in which one user PC also functions as a server.	Most users in a single building or closely spaced buildings that can be connected by cable. Server-based network with one designated server and connected PC workstations and other devices.
Software	Microsoft Office suite used for office functions and GIS uses ArcView and data stored in Microsoft Access database.	Microsoft Office suite used for office functions and GIS uses ArcView or MapObjects and data stored in Microsoft Access database. Some “add-on” off-the-shelf application packages are purchased.
Database	Implement system with existing digital data (i.e., DOQQ orthoimagery, DRGs, street centerlines from Kentucky OGI Web site, and general water/sewer facility data from KWRDC). Map centroid locations for parcels (no parcel boundaries). Data entry and link parcel attribute database information. Gradually, over a period of years, digitize parcel boundaries and other data.	Use existing DOQQ orthoimagery from Kentucky OGI with option to acquire more detailed resolution imagery (new aerial photography and 1-foot resolution orthos) for densely populated areas. Use existing street centerlines from Kentucky Transportation Cabinet and update where necessary. Load water/sewer data from KWRDC and enhance detail and accuracy where needed. Digitize parcel boundaries from PVA office. Digitize and load other data as needed.
Applications	Basic map display, general query and display of parcel data, basic query and mapping of parcel information.	Standard generation of parcel and utility maps. Full range of map query and display. Mapping and analysis of all address data. Special thematic mapping and other more complex applications.
Staffing	Train existing staff person to provide technical support and rely on vendor or consultant for special support and development. Secure GIS software support through annual maintenance agreement on license. An ongoing training program should be established to support the individual and expand their proficiency with new products. Initial training may cost between $1,500 and $4,000.	A full-time GIS technician would likely be needed to manage a moderate-size implementation. While it is possible to train in-house staff to perform this role, it will probably be necessary to hire someone. Typically starting salary costs for a GIS specialist are between $35,000 and $50,000 per year.
Funding/ Financial Support	The infrastructure (hardware, software, etc.) costs for a small system will typically range from $2,500 to $3,500 for a single stand-alone workstation and basic peripheral devices to $10,000 to $15,000 for a more complete setup to capture data and produce maps. Annual operating costs, including salary for a dedicated half-time employee, would approach $15,000 to $25,000. By far, data capture represents the largest category cost for local governments, and up to $25,000 should be budgeted annually to enter parcel boundaries, convert hard copy maps, and digitize infrastructure.	Infrastructure costs for a moderate size system may approach $15,000 to $45,000, depending on the availability of network communications. Annual operating costs, as listed above, could approach $45,000. Without the inclusion of special projects, such as obtaining aerial photography, the cost would be roughly the same as for a small system.

at least initially, on the basic program functionality that is provided with the GIS software that is purchased.

In some cases, agencies may be capable of performing these studies and development activities internally. For others, however, it will be necessary to secure competent professional assistance. Possible options for obtaining assistance include hiring a GIS consultant or requesting advise from the Kentucky Office of Geographic Information or the appropriate Area Development District. Both the Office of Geographic Information and the Area Development Districts may, however, be able to only commit limited resources to support local government efforts to develop GIS. Other alternatives that are receiving increasing attention include developing multiagency or multiparticipant GIS partnerships and contracting with private GIS consultants (known as ASPs) to build and maintain the entire GIS for a local government or partnership.

Appendix A: Additional Sources of Help

This appendix contains references to materials and sources of information for those interested in finding out more information about GIS and options for implementation.

Introductory GIS Books

Antenucci, John C., Kay Brown, Peter Croswell, Michael Kevany, Hugh Archer, *Geographic Information Systems: A Guide to the Technology*. Chapman & Hall, 1991.

Beck, John and Mary Tsui. *Aerial Imagery Guidelines.* Urban and Regional Information Systems Association (URISA), 1999.

Bernhardsen, Tor. *Geographic Information Systems: An Introduction*. John Wiley & Sons, Second edition, 1999.

Burrough, Peter and Rachael McDonnell. *Principles of Geographical Information Systems*. Oxford University Press, Second edition, 1998.

Chrisman, Nicholas. *Exploring Geographic Information Systems*. John Wiley & Sons, 1997.

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GIS Magazines

EOM (Earth Observation Magazine)
EOM, Inc.
13741 E. Rice Place, Suite 200
Aurora, CO 80015
Phone: 303-690-2242; Fax: 303-690-2522
Web Site: http://www.eomonline.com
Published Monthly
Yearly Subscription Price: $52.00 (US), $65.00 (Canada), $107.00 (Outside US and Canada)

GeoInfo Systems
Advanstar Publishing
131 W. First Street
Duluth, MN 55802-2065
Phone: 541-343-1200
Telex: 510-597-0365
Fax: 541-344-3514

URISA Journal
Urban and Regional Information Systems Association
1460 Renaissance Drive, Suite 305
Park Ridge, IL 60068
Phone: 847-824-6300
Web Site: http://www.urisa.org
Published three times a year
Yearly Subscription Price: $77.00 (US), $100.00 (All Other Countries)

Utility Automation
PennWell
1421 S. Sheridan Road
Tulsa, OK 74112
Phone: 918-835-3161; Fax: 918-831-9834
E-mail: ua@pennwell.com
Web Site: http://www.pennwell.com
Published Monthly
Yearly Subscription Price: $65.00 (US), $72.00 (Canada and Mexico), $160.00 (All Other Countries)

Utilities IT (Information Technology for Utilities)
The McGraw-Hill Companies
148 Princeton-Hightstown Road
Hightstown, NJ 08520-1450
Phone: 609-426-5667; Fax: 609-426-7635
Web Site: http://www.itforutilities.com
Published Bi-monthly
Yearly Subscription Price: $55.00 (US), $150.00 (All Other Countries)

GIS Resource Web Sites

AAG (Association of American Geographers)
1710 Sixteenth Street NW
Washington, DC 20009-3198
Phone: 202-234-1450; Fax: 202-234-2744
Web Site: http://www.aag.org

The AAG is a scientific and educational society that focuses on the theory, methods, and practice of geography. A large percentage of its members are geography professors. They publish two academic journals.

ESRI Store
380 New York Street
Redlands, CA 92373-8100
1-800-447-9778 (orders)
http://gisstore.esri.com/

ESRI, the software vendor, has an on-line store where you can order books, software, data, documentation, and other items.

GeoPlace.com from Adams Business Media
2101 S. Arlington Heights Road, Suite 15
Arlington Heights, IL 60005
Phone: 847.427.9512, Fax 847.427.2079
http://www.geoplace.com/

The publisher of *GeoWorld* magazine has an on-line bookstore, which is a link to IndustryBooks.com, a supplier of GIS books in a number of areas. The site is also useful for industry news, periodical searches, etc.

GITA (Geospatial Information and Technology Association)
14456 East Evans Avenue
Aurora, CO 80014
Phone: 303-337-0513; Fax: 303-337-1001
Web Site: http://www.gita.org

GITA is a non-profit educational association that focuses on applying GIS, Automated Mapping/Facilities Management (AM/FM), Supervisory Control and Data Acquisition (SCADA). and related information technology applications for utilities, government agencies, and other organizations. The 1998 and 1999 GITA Conference Proceedings titles are searchable on-line and are available for purchase. There is a publications link.

Spatial Odyssey
University of Maine/NCGIA
http://wwwsgi.ursus.maine.edu/gisweb/home.html

Spatial Odyssey is a GIS literature database that provides information on how to access the table of contents of GIS journals or their abstracts through commercial databases, provides listings of the contents of many GIS conference proceedings and published collections of articles, and provides access to the full text of selected GIS conference proceedings articles. Somewhat outdated, but still useful.

URISA (Urban and Regional Information Systems Association)
1460 Renaissance Drive, Suite 305
Park Ridge, IL 60068
Phone: 847-824-6300; Fax: 847-824-6363
http://www.urisa.org

URISA is a non-profit organization for the spatial information industry. Its Web site features a wide variety of links, areas, and GIS information, all with a public sector focus. The *URISA Journal* can now be read on-line through the site. The URISA Store is a good place for resource materials, books, videos, etc.

GIS Learning Opportunities

ESRI Virtual Campus
380 New York Street, Redlands, CA 92373-8100
Phone: (909) 793-2853; Fax: (909) 307-3025
http://campus.esri.com/index.cfm?theme=usa

ESRI, the software vendor, has an on-line virtual campus for self-paced GIS training on the Web with more than a dozen courses on GIS applications. The access to reference material, the library, help, chat rooms, and discussion groups is very useful and free. Some modules are free.

GITA (Geospatial Information and Technology Association)
14456 East Evans Avenue
Aurora, CO 80014
Phone: 303-337-0513; Fax: 303-337-1001
Web Site: http://www.gita.org/events/events.html

GITA, a non-profit professional association with an emphasis on utility and infrastructure management, hosts a wide variety of conferences and seminars pertinent to GIS. They also have an awards program and a number of local chapters.

Kentucky OGI (Kentucky Office for Geographic Information)
23 Millcreek Park, Bldg. 2
Frankfort, Kentucky 40601
Phone: (502) 573-1450; Fax: (502) 573-1458
http://www.state.ky.us/agencies/finance/depts/ogis/gisdept.htm

Link offers a listing of GIS software training courses available in the state. The annual state GIS conference, held in May or June of each year, includes workshops, technology exhibitions, and presentations from state and national GIS practitioners. (Note: The 2000 conference is June 5–8 in Bowling Green)

NCGIA (National Center for Geographic Information and Analysis)
http://www.ncgia.ucsb.edu/
Core "GIScience" Curriculum and other links.

PennState World Campus
http://www.worldcampus.psu.edu/pub/programs/gis/index.shtml

On-line GIS Certificate Program offers a certificate in under 12 months by taking four ten-week courses. (NOTE: requires GeoMedia Pro GIS software).

Purdue University
http://pasture.ecn.purdue.edu/~caagis/tgis/getstart.html

List of on-line GIS courses. The course is served in an on-campus PUCC lab with projects and data contained on a CD-ROM. You need to have ArcView installed with the spatial analyst extension, if you want to work the examples included in the ArcView training.

University of Texas Virtual Geography Department
http://www.utexas.edu/depts/grg/virtdept/contents.html

List of on-line GIS related courses at different universities (some have course notes).

URISA (Urban and Regional Information Systems Association)
1460 Renaissance Drive, Suite 305
Park Ridge, IL 60068
Phone: 847-824-6300; Fax: 847-824-6363
http://www.urisa.org/educatio.htm

URISA, a non-profit organization, hosts numerous educational offerings, including an annual conference on government information technology and spatial information systems; regional educational programs focused on specific topics; and day-long intensive workshops. These programs provide continuing education for IT/GIS Professionals, who serve and support state and local governments. They host awards and have a number of local chapters.

Contacts

1. Kentucky Office of Geographic Information (OGI): (502) 573-1450. See Web site: http://ogis.state.ky.us

2. Kentucky Transportation Cabinet (KTC) - Information Technology Division or Planning Division: (502) 564-8900 or (502) 564-7183

3. Kentucky Water Resources Development Commission (KWRDC): (502) 573-2382. See Web site: http://dlgnt1.state.ky.us/wrdc

4. Kentucky Department for Local Government: (502) 573-2382

5. Kentucky Geological Survey (KGS): (606) 257-5500. See Web site: http://www.uky.edu/KGS/gis/kgs_gis.html

6. U.S. Department of Agriculture. Natural Resources Conservation Service. National Soil Survey Center: See Web site: http://www.ftw.nrcs.usda.gov/soils_data.html

7. Federal Emergency Management Agency (FEMA): (800) 358-9616. See Web site: http://www.fema.gov/MSC/product.htm

8. Kentucky Natural Resources and Environmental Protection Cabinet (KNREPC) – Office of Information Services: (502) 564-5174. See Web site: http://nrweb1.nr.state.ky.us/nrgis

Appendix B: Glossary

Accuracy—The closeness of observations to true values or values accepted to be true. Accuracy relates to the quality of a result and is distinguished from precision, which relates to the quality of the operation by which the result is obtained. In common GIS practice, accuracy frequently refers to positional accuracy (“plus or minus X meters”)

Address matching—A procedure that allows two geographic data files to be related through a common address field. Address matching often refers to the assignment of an x-y coordinate based on a given street address. Attribute files with addresses can be matched to geographic base files with address ranges.

Aerial orthophotography—The art or process of taking photographs from an aircraft. Also called aerophotography.

AutoCAD—Computer aided design. An automated system for the design, drafting, and display of geographically oriented information.

AM/FM—Automated mapping/facilities management, a class of geographic data applications often applied in the public works and utility industry and related applications.

Arc-second—A unit of angle defined to be 1/60 of a minute, or 1/3600 of a degree, of latitude or longitude.

Area—A generic term for a bounded, continuous, two-dimensional object that may or may not include its boundary.

Attribute—A defined characteristic of an entity type.

Attribute value—A specific quality or quantity assigned to an attribute, for a specific entity instance.

Base Map—A map on which information can be placed for comparison or for geographic correlation. The term base map was at one time applied to a class of maps now known as outline maps. A map from which other maps are prepared by adding information—in particular, planimetric maps used in preparing topographic maps.

Bathymetry—The art or science of determining depths of oceanic or other deep waters.

Cadastral reference system—In general, surveys carried out for establishing the boundaries and subdivisions of public lands or for establishing land tenure systems.

Centerline—A line, imaginary or real, delineating the center of a linear feature. The centerline may be measured or derived from the real boundaries of the feature.

Certification—The procedure and action by a duly authorized body of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with applicable requirements. For the framework, it is to be certified that data comply with framework standards and are suitable for inclusion in the framework. (See data certification.)

Chain—A direct non-branching sequence of nonintersecting line segments and/or arcs bounded by nodes, not necessarily distinct, at each end.

COGO—Abbreviation of the term COordinate GeOmetry. Land surveyors use COGO functions to enter survey data, to calculate precise locations and boundaries, to define curves, etc. The name of the coordinate geometry software product for ArcInfo..

Coordinate referencing system—A set of points, lines, and/or surfaces and a set of rules whereby each point in a given space can be identified uniquely by a set of numbers.

Coordinates—A set of numeric quantities that describe the location of a point in a geographic reference system. A coordinate pair describes the location of a point or node in two dimensions (usually x-y), and a coordinate triplet describes a point in three dimensions (x-y-z). A series of points (two or more) is used to describe the locations of chains and the edges of areas.

Data certification—A framework term referring to the process by which potential framework data are evaluated against framework standards and deemed suitable for inclusion in the framework. (See certification.)

Data model—In a database, the user's logical view of the data structure, entities, and relationships (in contrast to the physically stored data or file storage structure). A description of the organization of data in a manner that reflects the information structure of an enterprise or a theme.

Database —A collection of information related by a common fact or purpose.

Datum—Any quantity, or set of such quantities, which may serve as a reference or basis for calculation of other quantities. In framework and GIS discussions, "datum" usually refers to a set of quantities that serve as a reference for the calculation of positions. A horizontal datum is the set of constants specifying the coordinate system to which horizontal coordinates are referred. A vertical datum is a set of constants specifying the coordinate system to which elevations are referred. In a linear referencing system, the datum serves as the basis for locating the linear referencing system in the real world and consists of a connected set of anchor sections that have anchor points at their junctions and termini.

Demography—The statistical study of human populations, particularly with reference to size, constitution, density, and distribution.

Digital Line Graph (DLG)—Digital representation of planimetric map features shown especially on topographic quadrangles.

Digital orthoimage—A digital representation (raster format) of an orthoimage. The digital image is composed of pixels whose dimensions define the minimum unit of resolution (expressed in distance on the ground).

Digital orthophotograph—An aerial photograph that has been draped over an accurate three-dimensional ground model to produce a photograph that meets National Map Accuracy Standards.

Digitize—To encode map features as x,y coordinates in digital form. To employ a digitizing tablet to record x,y or x,y,z values for map features (z values are either altitude values or some other point values which may be interpolated to create a continuous surface map.) Lines are traced to define their shape. A digitizer button, pressed periodically along the line, records x,y coordinates. Thus a digitized line is a series of x,y coordinates.

Digitizing tablet—A device that consists of a table and a cursor with crosshairs and keys used to record the locations of map features as x,y coordinates.

Digital Ortho Quarter Quad (DOQQ)—An aerial photograph created at 1" = 1000' scale with a one-meter pixel resolution that has been orthorectified to produce a horizontal accuracy of approximately 10 meters. DOQQs are usually black and white aerial photographs and are produced by the United States Geological Survey (USGS). In Kentucky, a DOQQ generally covers an area approximately 20,000 feet x 25,000 feet (approximately 18 square miles.)

Digital Raster Graphic (DRG)—A scanned image of a U.S. Geological Survey (USGS) standard series topographic map, including all map collar information. The image inside the map neatline is georeferenced to the surface of the earth and fit to the Universal Transverse Mercator projection. The horizontal positional accuracy and datum of the DRG match the accuracy and datum of the source map. The map is scanned at a minimum resolution of 250 dots per inch. KYOGI DRGs are projected in State Plane North and South Zone NAD 83 and seamless. (Collars have been removed.)

DLG—See Digital Line Graph.

Elevation—(1) The vertical distance from a datum to a point or object on the earth's surface; (2) the measurement of the height of terrain on the earth's surface, or the depth of deep waters.

Ellipsoid—In geometric terms, a closed surface of which all planar sections are ellipses. In general framework, GIS, and mapping practices, an ellipsoid is a specific mathematical representation of the earth that more closely approximates the shape of the surface than a sphere does.

Ellipsoid height—The distance between a reference ellipsoid and a point, measured along the ellipsoidal surface normal through the point. The Global Positioning System provides ellipsoidal heights. (See also orthometric height.)

Entity—A real world phenomenon of a given type. An entity instance is an occurrence of an entity. An entity type is the definition and description of a set into which similar entity instances are classified.

Feature—A defined entity and its object representation. A real world feature is used in framework discussions to emphasize the goal that framework data should be based on the original encoding of an observation, or be removed from an observation by the fewest possible generations or interpretations.

Federal Geographic Data Committee (FGDC)—The Federal Geographic Data Committee coordinates the development of the National Spatial Data Infrastructure (NSDI). NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector.

Federal Emergency Management Agency (FEMA)—An independent agency of the federal government, reporting to the President. Since its founding in 1979, FEMA's mission has been to reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response, and recovery.

FGDC—See Federal Geographic Data Committee.

Framework—The NSDI framework is an initiative to develop a readily available set of basic geographic data. It includes the information, operational environment, and technology to provide access to these data, and the institutional setting to sustain its development.

Framework data—Seven themes of geospatial data (geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information) used by most GIS applications. These data include an encoding of the geographic extent of the features and a minimal number of attributes needed to identify and describe the features.

Functional class—The characterization of a certain portion of a highway system based on its purpose. The framework employs the classification published by the American Association of State Highway and Transportation Officials (AASHTO), which is used widely in the transportation community.

Generalization—Reduction in detail in geographic data representation; for example, resampling elevation or image data to a larger spacing or reducing the number of points in a line.

Geocode—A location identifier. Geocode also denotes the process of assigning a geocode. In common GIS practice, geocoding frequently refers to assigning an x,y location to an address (also called address matching).

Geodetic control—A network of geodetic control points, or a set of known reference positions, used as a basis for obtaining positions of other features. A geodetic control point has precisely determined coordinates from which the location of other features or points can be spatially referenced. Geodetic control points are frequently called benchmarks—especially when they have a known elevation.

Geographic information system (GIS)—A computer system for the input, editing, storage, maintenance, management, retrieval, analysis, synthesis, and output of geographic, or location-based, information. In the most restrictive usage, GIS refers only to hardware and software. In common usage, it includes hardware, software, and data. When organizations refer to their GIS, this latter usage is usually what they mean. For some, GIS also implies the people and procedures involved in GIS operation. In this guide, the common usage—hardware, software, and data—is intended unless specifically stated as GIS hardware and software.

Geoid—The equipotential surface of the earth's gravity field that best fits, in a least-squares sense, mean sea level; less formally, the figure of the earth considered as a sea-level surface extended continuously through the land masses.

Geospatial data—Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. The information may be derived from—among other things—remote sensing, mapping, and surveying technologies.

GeoTIFF format—A raster image format that allows coordinate values to be embedded within raster data. The Kentucky Office of GIS has recently converted all of the DOQQ images from BIL format to GeoTIFF format.

GIS—See geographic information system.

Global Positioning System (GPS)—A satellite-based navigation system deployed by the Department of Defense used to determine locations on the earth's surface.

Governmental units—The geographic extent of units of government, including the nation, states, counties, incorporated places, and consolidated cities; functioning and legal minor civil divisions such as towns and townships; federal- or state-recognized American Indian reservations and trustlands; and Alaskan Native regional corporations.

GPS—See Global Positioning System.

Grid—(1) Two sets of parallel lines intersecting at right angles in a plane coordinate system; (2) A set of cells or points arranged in a grid.

Grid coordinate system—A plane-rectangular coordinate system usually based on a rigorous mathematical map projection so that easily expressed plane coordinates (x,y) can be used in place of latitude and longitude.

Heads-up digitizing—Digitizing in GIS software is called "heads-up digitizing." The basic process is drawing shapes on a screen using a digital photo, a scanned quad map (DRG), etc., as a backdrop. The resultant product is a vector or point map of data which was digitized during the session.

Hydrography—Surface water features, such as streams and rivers, lakes and ponds, canals and ditches, and oceans.

Integration—A term referring to the processes required to compile a consistent set of data from different sources.

Layer—A logical set of thematic data described and stored in a map library. Layers organize a map library by subject matter (e.g., soils, roads, and wells), and extend over the entire geographic area defined by the spatial index of the map library.

Linear referencing method—A mechanism for finding and stating the location of any point along a network by referencing it to a known point. There are many kinds of linear referencing methods (e.g., mile point, reference post, and engineering stationing). All linear referencing methods consist of traversals and associated traversal reference points that together provide a set of known points, a metric, and a direction for referencing the locations of unknown points.

Linear referencing system—A set of datums, networks, and linear referencing methods, whereby each point along a network can be identified uniquely by specifying the direction and distance from any known point on the network.

Map projection—A systematic method of representing the whole or part of the curved surface of the earth on another, usually flat, surface. The latitude/longitude values of framework data can be converted to any map projection.

Map scale—The extent of reduction needed to display a representation of the Earth's surface on a map. A statement of measure on the map and the equivalent measure on the Earth's surface, often expressed as a representative fraction of distance, such as 1:24,000 (one unit of distance on the map represents 24,000 of the same units of distance on the Earth). Map scale can also be expressed as a statement of equivalence using different units. For example, 1 inch = 1 mile or 1 inch = 2,000 feet.

Metadata—Data about the content, quality, condition, and other characteristics of data.

MrSID Compressed Image—MrSID (Multi Resolution Seamless Image Database) is a compressed raster image format. Typical DOQQ images in GeoTIFF format require approximately 45 Megabytes of storage space. The MrSID compressed format only requires 2 to 3 megabytes of storage per DOQQ. The Kentucky Office of GIS has recently converted all of the State's DOQQ images to MrSID format. These MrSID files are available for downloading on this Raster Image Server.

National Geospatial Data Clearinghouse—A distributed network of geospatial data producers, managers, and users linked electronically. Building on initiatives such as the National Information Infrastructure, the clearinghouse uses a distributed, electronically connected network, such as the Internet. Each data provider describes available data in an electronic form and provides these descriptions (or metadata) using means that can be accessed over a communications network. Thus, the data for the clearinghouse are located at the sites of data producers (or, where more efficient, at the sites of intermediaries) throughout the country. Using the network, users will search these descriptions to locate data that are suitable for their applications.

National Spatial Data Infrastructure (NSDI)—The technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data. NSDI is an umbrella under which organizations and technology interact to foster activities for using, managing, and producing geographic data.

National Hydrography Dataset (NHD)—A comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order. NHD is based upon the content of USGS Digital Line Graph (DLG) hydrography data integrated with reach-related information from the EPA Reach File Version 3 (RF3). NHD supersedes DLG and RF3 by incorporating them, not by replacing them. Users of DLG or RF3 will find the National Hydrography Dataset both familiar and greatly expanded and refined.

NHD—See National Hydrography Dataset.

Node—A zero-dimensional object that is the topological junction of two or more chains or an end point of a chain.

NSDI—See National Spatial Data Infrastructure.

Orthoimage—An aerial photograph or satellite image from which displacements caused by terrain relief and sensor tilt have been removed. The result combines the image characteristics of a photograph with the geometric qualities of a map.

Orthometric height—The distance between the geoid and a point, measured along the vertical through the point and taken positive upward from the geoid. Also called orthometric elevation. Orthometric heights are used in topographic mapping. (See also ellipsoid heights.)

Orthorectification—The process performed on aerial photography to produce digital orthophotography. Orthorectification involves draping digital copies of the aerial photography over an accurate three-dimensional ground model to produce a spatially accurate digital orthophotograph.

Parcel—A single cadastral unit, which is the spatial extent of the past, present, and future rights and interests in real property.

Permanent feature identification code—A unique identification code that is assigned to a feature and does not change unless the existence of the feature does.

Photogrammetry—The science and art of deducing the physical dimensions of objects from measurements on photographs. For framework purposes, the principal application is aerial photogrammetry, in which the photographs are taken of the earth from aircraft or satellites.

Pixel—A two-dimensional picture element that is the smallest non-divisible element of a digital image.

Planimetry—The theory and practice of measuring areas of figures on a plane. The determination of horizontal distances, angles, and areas from measurement on a map. The determination of horizontal distances, angles or areas by photogrammetric methods. Horizontal measurements. The information contained, in a map, on horizontal distances and angles. Those parts of a map which represent everything except relief, that is, those parts which represent the works of man and natural features such as woods and water.

Plotter—A device capable of converting data in the form of coordinates into a graphical form as points, lines, or surfaces. Alternatively, a device capable of preparing drawings. Most plotters draw lines on a sheet according to instructions given by a computer or as forced by mechanical or optical linkages to a mark moving in a stereoscopic image. Some plotters create the drawing by focusing a directed beam of light onto a photographic emulsion.

PLSS—See Public Land Survey System.

Point—A zero-dimensional object that specifies geometric location. One coordinate pair or triplet specifies the location.

Precision—A measure of the quality of the method by which measurements are made. Precision is exemplified by the number of significant figures stated as a result of the measurement.

Projection—See map projection.

Public Land Survey System (PLSS)—The survey carried out by the Bureau of Land Management and its predecessors for establishing boundaries and subdivisions of public lands of the United States, using the rules embodied in the U.S. Public Land System. The system is frequently used for designating the locations of a parcel of land.

Quadrangle map—The best known USGS maps are those of the 7.5-minute, 1:24,000-scale quadrangle series. A scale of 1:25,000 is used for maps based on metric units (1 centimeter = 0.25 kilometer). The area portrayed on each sheet ranges from 64 square miles at latitude 30 degrees north to 49 square miles at latitude 49 degrees north. A scale of 1:24,000 allows considerable detail to be shown in the quadrangle areas. It takes about 57,000 maps to cover the conterminous 48 states, Hawaii, and territories. All of these maps are now for sale to the public. (For Alaska, 7.5-minute maps at 1:24,000 and 1:25,000 scale are available for areas around Anchorage, Fairbanks, and Prudhoe Bay.) The sheet size is about 22 x 27 inches north of latitude 31 degrees and 23 x 27 inches south of that latitude.

Raster data model—A spatial data model in which the locations of entities are represented using an array of cells or points that hold values for attributes.

Referencing system—A set of datums and rules by which the location of each point can be identified uniquely.

Registration—The process of matching details in separate data sets so that corresponding data are coincident.

Resolution—A measure of the finest detail distinguished in an object or phenomenon. For images, resolution also refers to the pixel size.

Scale—See map scale.

Server—A server is a piece of hardware that supports a central database and access to users. It also provides computing resources to support query and display operations from PCs.

Shoreline—The boundary line between a body of water and the land.

Spatial analysis—The process of modeling, examining, and interpreting model results. Spatial analysis is the process of extracting or creating new information about a set of geographic features. Spatial analysis is useful for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding. Spatial analysis is often referred to as modeling. In GIS, there are four traditional types of spatial analysis—spatial overlay and contiguity analysis, surface analysis, linear analysis, and raster analysis.

Spatial Data Transfer Standard (SDTS)—A standard format for transferring spatial data.

Soil Survey Geographic (SSURGO)—Field mapping methods using national standards are used to construct the soil maps in the Soil Survey Geographic (SSURGO) database. Mapping scales generally range from 1:12,000 to 1:63,360; SSURGO is the most detailed level of soil mapping done by the Natural Resources Conservation Service (NRCS). SSURGO digitizing duplicates the original soil survey maps. This level of mapping is designed for use by landowners and townships, and for county natural resource planning and management. The user should be knowledgeable of soils data and their characteristics.

State Plane Coordinate System—The plane-rectangular coordinate systems established by the National Geodetic Survey for defining positions in terms of plane-rectangular (x-y) coordinates. There is one system for each state in the United States; however, some states have more than one projection zone.

Theme—A topic or subject. The framework's data themes are geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information.

Triangulated Irregular Network (TIN)—A surface representation derived from irregularly spaced sample points and breakline features. The TIN data set includes topological relationships between points and their proximal triangles. Each sample point has an x,y coordinate and a surface, or z value. These points are connected by edges to form a set of non-overlapping triangles used to represent the surface. TINs are also called irregular triangular mesh or irregular triangular surface models.

Topographic map—A map containing contours indicating lines of equal surface elevation (relief), often referred to as a topographic map. Often used to refer to a map sheet published by the U.S. Geological Survey in the 7.5-minute quadrangle series or the 15 minute quadrangle series.

Topology—A branch of geometrical mathematics concerned with order, contiguity, and relative position rather than actual linear dimensions. Topology is used to establish and describe spatial relationships among geographic entities.

Transaction—A unit of processing activity that accomplishes a specific purpose such as a retrieval, an update, a modification, or a deletion of one or more data elements in a storage structure. In the framework, transactions are offered as the preferred means of updating holdings of framework data.

Transportation—Features used to move people and goods from place to place, including roads, trails, railroads, ports, airports, waterways, and related features such as bridges and tunnels.

Vector data model—A spatial data model in which the location of entities is represented using points, nodes, chains, and areas.

Sources:

Understanding GIS, ESRI

Glossary of the Mapping Sciences, ASCE, ASPRS, ACSM, & ASCE

GIS/Mapping Terms Glossary, A Compilation. Kentucky GOT, OGI